ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. LV. No. 12. 220 Broadway, New York, March 22, 1906.

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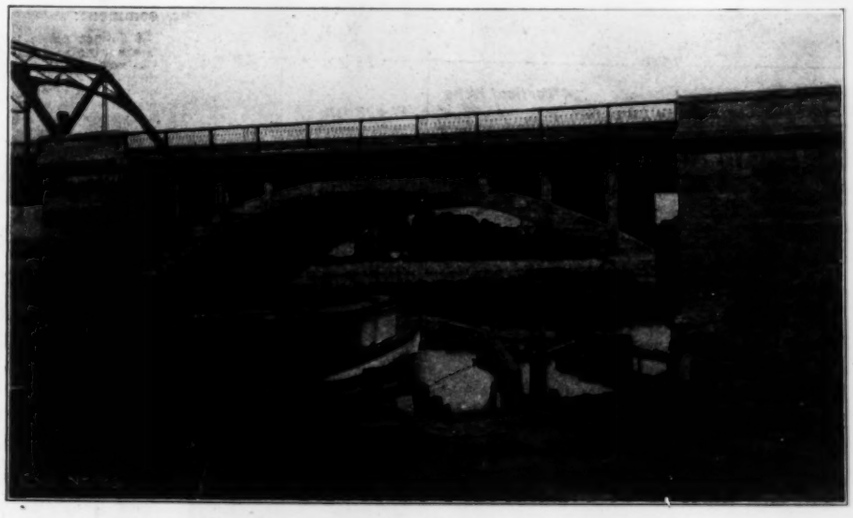
ARCH RIB BRIDGE OF REINFORCED CONCRETE AT GRAND RAPIDS, MICH.

By George Jacob Davis.*

A reinforced-concrete arch bridge of a type unusual in this country was built last year at Grand Rapids, Mich., on the line of Wealthy Ave., forming an approach to the steel truss bridge across Grand River. The arch of 75-ft. span crosses an old steamboat channel which was to have been filled on completion of the steel bridge, but a disastrous flood which occurred in the river during the spring of 1904 convinced the authorities that it would be inadvisable to restrict the waterway. A short-span truss placed adjacent to the 324-ft. draw span of the steel bridge would have appeared inharmonious, so the arch bridge was decided upon, although it involved considerable additional expense. The end pier of the draw-span, which had been built as an abutment, was 42.3 ft. high, and the springing line of the arch was 22.8 ft. above the base of the pier, which was 15 ft. wide. In order to prevent the overturning of the pier by the end thrust of the arch the latter was made as light as was possible. Other advantages of the design are a slight increase in waterway through the open spandrels, which is of value since the highest floods reach nearly to the crown of the arch, and also a better harmonizing of the arch with the steel bridge owing to the light appearance of the posts and ribs.



ARCH RIB BRIDGE OF REINFORCED CONCRETE AT GRAND RAPIDS, MICH.

GENERAL DESCRIPTION. — The structure consists of seven parallel, parabolic arch ribs, side by side, supporting a slab and girder floor by means of columns, Figs. 1 and 2. The five ribs under the 21-ft. roadway are each 2 ft. wide, 50 ins. deep at springing and 32 ins. deep at crown. The two ribs under the sidewalks are each 1 ft. wide, 50 ins. deep at springing and 25 ins. deep at crown. The soffits are all shaped to the same curve of three centers, approximating very closely a parabola of 14 ft. rise and 75 ft. span. The linear arch of the main ribs has a rise of 12.7 ft. and of the side ribs 12.4 ft. The ribs are connected and braced by 4-in. reinforced-concrete slab webs lying near the neutral axis of the ribs. These were deemed necessary to stiffen the ribs to resist the impact of floating ice and debris during the high water of spring freshets and also to prevent side buckling due to the bending stresses of the loading. The webs extend between the main ribs from each abutment to the second row of columns, and between the outer ribs and those adjacent they extend to the third row of columns. The outer ribs are further braced by 8x8-in. concrete struts, one at each of the three middle columns. The longer columns also are connected by 4-in. vertical webs of reinforced concrete. The columns under the roadway are 12x12 ins., with a 1-in. chamfer on the corners. The sidewalk columns are 10x12 ins., chamfered. The sidewalk slabs are 9 ft. wide and 4 ins. thick and overhang the 6x12-in. longitudinal beams a distance of 3 ft. The tension in these cantilever slabs is carried by ½-in. bars 8 ins. c. to c., the brackets underneath being for appearance only. The roadway was built in the form of a trough 2 ft. deep below the tops of the curbs, as shown. This trough is now filled with cinders, capped with a 4-in. creosoted block pavement laid on a concrete foundation, but it is intended to accommodate the ties and ballast for an electric railway should one be extended in that direction in the future. The floor of the trough is an 8-in. reinforced-concrete slab, supported by longitudinal girders 5 ft. 6 ins. c. to c.

The west abutment of the arch was made by cutting off the wing-walls of the abutment that had previously been constructed for the steel bridge, and building on to the remainder a reinforced-concrete box braced with buttresses of the same material. The walls of the abutment, which was later filled with earth for the sake of its weight, were 9 ins. thick above the springing line of the arch. From this line they battered to 13 ins. thick 6 ft. below, and continued with this thickness to the bottom, which rests on limestone rock. The buttresses were 12 ins. thick except those taking the thrusts of the arches. These were 2 ft. thick below the level of the arch ribs. The new work was tied to the old by a large number of bars grouted into holes drilled into the concrete.

The east abutment rests on a bed of indurated clay. It is built on the same general plan as the west abutment; a thin concrete shell, tied in by buttresses, holding the earth filling. A low wing-wall was built on the south side to hold the toe of the earth slope. This wall was 1 ft. thick and 12 ft. high, the top being only slightly above average low water. The sides of the abutment were carried eastward further than the base in the form of cantilever wings conforming to the slope of the earth embankment, which was 1½ to 1.

All of the reinforcement in the abutments and bridge except a small amount in the stiffening webs and wing-wall is of high-carbon steel deformed rods of ½-in., ¾-in. and ⅞-in. sizes. Splices were made by lapping about 30 diameters.

CONSTRUCTION.—The work was done by day labor by the city's forces. The supply of common labor was at most times ample, but great difficulty was experienced in getting and keeping carpenters. The work of building the forms, Fig. 3, for the arch ribs was particularly tiresome owing to the difficulty of moving around on the steeply inclined sheathing and to the cramped positions in which the men had to work. Many men quit after a day's work simply because easier work could readily be procured elsewhere. Common labor was paid $1.75 per day. Carpenters were paid $3.50 and $3.

Excavating for the east abutment was disagreeable owing to a deposit several feet deep of tar from the gas works. This, mixed with the sludge in the bottom of the sluggish channel in which the abutment was built, formed a gummy compound most too fluid to shovel, but difficult to handle in any other way. It was taken out in iron wheelbarrows. Excavation for the two abutments was carried on simultaneously, requiring two pumps and engines, the structure being carried 12 ft. and 15 ft., respectively, below water at the east and west abutments. Some delay and increased pumping charges were incurred by the difficulty of removing the wing-walls from the old abutment. It was found that the concrete placed a year previously had set very hard. An attempt was at first made to break off small pieces at a time by wedges, but

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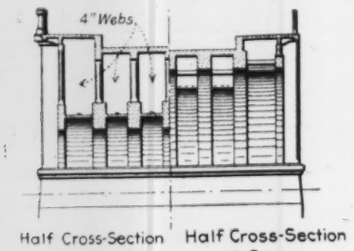
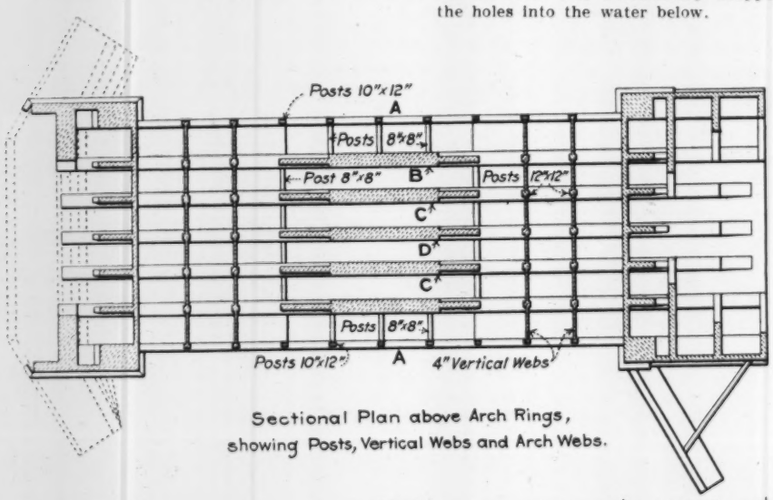
this method was soon abandoned, and the work was expedited by using small charges of dynamite. No injury resulted to the main portion of the abutment.

Work on the abutments was completed Feb. 1, 1905, and work was then suspended until spring on account of the difficulty of preventing the smaller masses of concrete in the arches and columns from freezing. Pockets were left in the faces of the abutments to receive the ends of the arches, and reinforcing bars were left protruding to tie the parts together. Concreting was done on the abutments at temperatures as low as 10° above zero. All gravel and water for concrete in the abutments was heated. No salt was used. When concreting was finished at night the work was covered with tarred felt, and usually the concrete was steaming the next morning. The mass when deposited in the forms was at a temperature of about 100° F. There was no trouble from freezing except in the first day's concreting on the west abutment. The gravel for that day's work had not been heated, and the concrete had not set hard the following morning. It was left in place, but the bottom was thickened.

The concrete was composed of Portland cement and bank gravel, in proportions of 1 to 7 for the abutments and 1 to 5 for the remainder of the structure. No mortar facing was used, but the concrete was mixed moderately wet and was well tamped. The concrete for the arch ribs and columns was of a mushy consistency. With a little pointing up a very satisfactory finish was obtained. The parapets were painted with cement grout. Mixing was done by a cubical mixer, operated by an electric motor. The mixer was placed at the east end of the bridge, the concrete being conveyed in wheelbarrows to the forms. Some trouble was caused by the armature of the motor, which was rented, binding and causing the fuses to blow out. An engine would have been more reliable and satisfactory. Water was supplied from the city mains.

The centering was lagged with short lengths of lumber which had been used for forms for the abutments, holes being left between the ribs, as can be seen in Fig. 2. A saving of lumber was effected in this way, but the difficulty of working on the forms was increased and a number of tools was accidentally dropped through the holes into the water below.





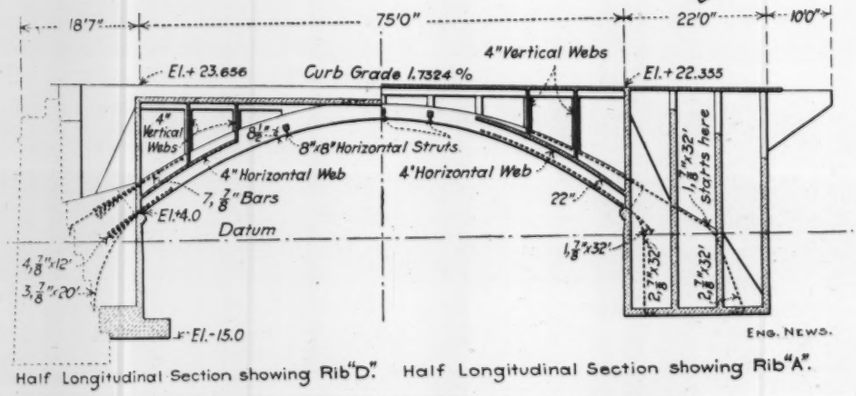


FIG. 1. GENERAL PLAN AND SECTIONS OF ARCH RIB BRIDGE.

The arch ribs were built complete in one operation, usually two ribs being placed in one day. The tops of the crowns were roughened to form a bond with the roadway slab and girders into which the main ribs merged. The reinforcement for the columns was placed when the arches were poured and extended nearly to the bottom of the ribs. After the ribs had all been cast and had set the forms for the inclined and vertical webs, posts, girders and floor slab were constructed, and the concreting for all was done in one operation. The arches are without hinges or joints, but expansion joints of tarred felt and tar were made across the bridge at the center and two abutments, the center joint extending through the slabs to the arch ribs and columns.

The bridge is designed to carry a 15-ton road roller or a 24-ton electric car, or a uniform load of 250 lbs. per sq. ft. on the roadway and 100 lbs. per sq. ft. on the sidewalks. A factor of safety of two for dead loads and four for live loads was used. The slabs and girders were figured as simple beams. Straight horizontal bars only were used in the girders. The ribs were reinforced against shearing by bars [illegible] into a figure 8. The narrowness of the ri[illegible] them more likely to shear off sideways [illegible] to the tangential thrust, than to fail by [illegible] shearing due to the vertical forces. The [illegible] reinforcement adopted was intended to [illegible] against both methods of failure. The re[illegible]nt in the ribs was varied in the differe[illegible]ons in accordance with the variation of [illegible]resses

COST.—A record of the cost of [illegible]k was kept and is here presented. This [illegible] of work was new to all of the force engag[illegible] upon it and was done under adverse conditi[illegible] such as very cold weather rendering the la[illegible] efficient and unusually high water in the ri[illegible] requiring the removal of large quantities of [illegible]rial and causing delay. The work was com[illegible]nced before the plans were prepared, and the superintendent was therefore unable to pl[illegible]n the work ahead intelligently. The unit costs are therefore believed to be high, but are given for their relative value. The estimate of costs was started after the work was well under way and was made by tabulating the bills and apportioning the labor costs according to the notes in the superintendent's diary. When work was started in the spring the form shown in Fig. 4 was used for the labor costs, a report being filled out each day by the superintendent, showing the total hours worked by each class of labor. The amounts were then entered on monthly reports in the office. The work in the superstructure cost much more per yard than that in the abutments. Tables have been prepared separating the costs for the two classes of work. The design was made at the instance and under the direction of Mr. L. W. Anderson, City Engineer, by the author, who also kept the cost records. Mr. Wm. T. Johnson was superintendent of construction.

In conclusion, it may be stated that a copy of this article was submitted to Mr. Anderson for examination, and that he makes the following comment:

I do not agree with you in your statement relative to the engine and motor. While we had some trouble with the motor, which made delays, the trouble was not much in excess of what is commonly experienced with a steam engine and is not to be compared with the trouble experienced with a gasoline engine. If the motor had been in proper condition, we would have had practically no trou[illegible]ble. The cost of operating the motor is not to be compared with that of operating a gasoline engine, being very much lower. We are now concreting on flood protection work near Myrtle St. and using the same motor, and have practically decided to purchase it from the company. I believe it would pay a company working in the city to purchase a good motor for operating their mixers rather than an engine. It may be of interest to the readers to know the cost of cement and gravel. Will say that the Aetna cement costs about $1.05 delivered on the work. The Meluss cement, delivered in small quantities, costs $1.75 per bbl. Bank gravel costs 85 cts. per cu. yd. delivered and sand 66 cts.

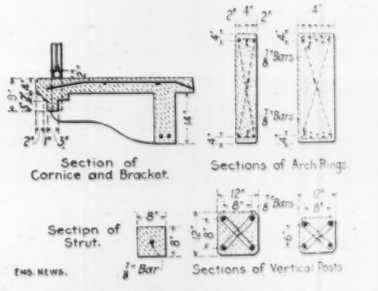


Fig. 2. Special Details of Arch Rib Bridge.

Cost of Reinforced Concrete Arch Approach, Wealthy Ave. Bridge, Grand Rapids, Mich.

Pumping:		
Fuel	$210.00	
Machinery, tools and cartage	283.00	
Labor	407.00	
Two engines and pumps. Total time = 110 days, at $9 for each plant		900.00
Excavation:		
Timber, cartage, etc.	$374.95	
Tools	48.55	
Labor	1,657.00	
		2,130.50
Filling Abutments and Approach:		
Earth, 5,711 yds., at 20 cts.	$1,142.20	
Labor (including riprapping)	396.50	
		1,538.70

Removing old Wing Walls:		
Labor and dynamite	$346.15	
Tools and sharpening	64.15	
		410.30
Hand Rail (150 lin. ft.):		
Material	$278.20	
Labor	28.90	
		307.10
Pavement (does not include concrete base):		
Wood block, etc.	$695.40	
Labor	57.00	
296 sq. yds., at $2.54		752.40
Engineering		450.70
Miscellaneous		74.50
Steel:		
Corr. bars, cartage and freight	$1,497.75	
Plain steel, wire, etc.	74.75	
Blacksmithing, tools and placing	438.00	
62,000 lbs., at 3.24 cts.		2,010.50
Centering:		
Lumber and piles	$332.02	
Labor	272.28	
		604.30
Forms		3,311.70
Concrete		5,532.30
		$18,113.00

Cost of Forms and Concrete in Arches, Slabs, Sidewalks, Roadway-Concrete, etc, 290 cu. yds.

	Cost per cu. yd. of concrete.	Total cost
Forms:		
Materials	$3.70	
Labor	3.03	$6.73 $1,951.44
Concrete:		
Materials	$3.22	
Labor	3.57	6.79 1,970.70
		$13.52 $3,922.14

A COURT DECISION AS TO DAMAGES FOR A CONTRACTOR'S DELAY.

By W. M. S.

An opinion was recently handed down by Judge McPherson, in the United States District Court for the Eastern District of Pennsylvania, in a suit by a general contractor against the United States to recover a certain sum which had been charged against the contractor's account as liquidated damages due on account of delay in the completion of the work beyond the time allowed by the terms of the contract, and had been retained by the Government.

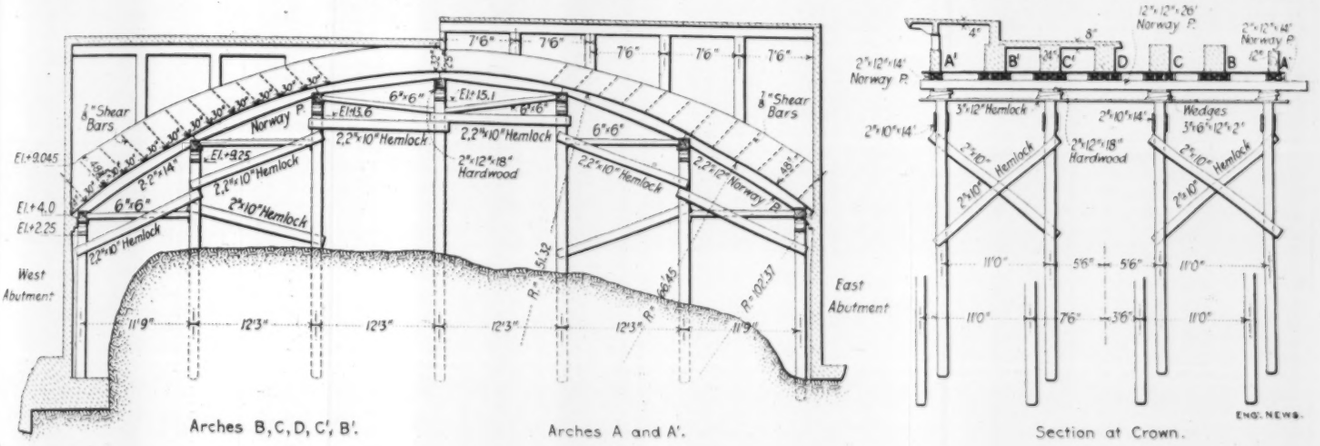


FIG. 3. CENTERS FOR ARCH RIB BRIDGE.

Detailed Cost of Forms and Concrete for Entire Structure, 884 cu. yds.

	Total cost.	Cost per cu. yd.
Forms:		
Lumber and cartage	$1,546.73	
Nails and bolts	129.03	
Tools	109.66	
Labor (erectg & remvg)	1,526.28	
	$3,311.70	$3.75
Concrete:		
Materials:		
Cement { Aetna $1,217.85 / Medusa 499.00 }		$1.94
Sand	36.85	
Gravel	915.00	1.07
	2,668.70	
Mixing:		
Machinery & supplies	$548.80	
Power	51.96	
Tools	22.44	
Labor	737.20	
	1,360.40	1.54
Placing	608.70	.69
Tamping	481.10	.54
Heating:		
Apparatus and cartage	46.90	
Fuel	98.30	
Labor	270.20	
	413.40	.47 6.25
	$8,844.00	$10.00

Cost of Forms and Concrete in Abutments and Wing-Walls, 594 cu. yds.

	Cost per cu. yd. of concrete.	Total cost.
Forms:		
Material	$1.20	
Labor	1.09	$2.29 $1,360.26
Concrete:		
Material	$2.92	
Labor	2.38	5.30 3,148.20
	$7.59	
Heating water & gravel:		
Fuel, labor, etc.	.70	413.40
	$8.29	$4,921.86

The contract required completion in seven months, and provided a charge of $10 per calendar day "as liquidated damages" for each day after the date completion was due until the work was actually finished. What constituted unavoidable delays was set forth in general terms in the contract, as follows:

"Unavoidable delays are such as result from causes which are undoubtedly or may reasonably be presumed to be beyond the control of the contractor, such as acts of Providence, unusual storms, fires (not the result of negligence), fortuitous events, inevitable accidents, etc. Delays caused by the Acts of the Government will also be regarded as unavoidable delays."

There was a further provision that if the work appeared likely to be delayed by causes believed by the contractor to be unavoidable, he should give notice in writing of the fact to the officer in charge, in order that a record might be made of the attendant circumstances. It was agreed that extensions of time would be allowed for unavoidable delays, such extensions carrying with them a corresponding remission of liquidated damages.

DAILY REPORT.

Date ____ Wealthy Avenue Arch.

	No. of Men	Centering	Forms	Mixing	Placing	Tamping	Steel		
Supt.									
Foremen									
Carpenters	$3.50								
"	$3.00								
Laborers	$1.75								
"	$2.00								Cog Ind'ct.

Fig. 4. Daily Report Card for Cost-Keeping Records.

The contractor urged as a cause of unavoidable delay his inability to secure certain structural steel required in the work, owing to the congested condition of the mills, and the question was presented to the court whether a contractor is liable for delay caused by the inability of a manufacturer to furnish material on time, or, in other words, whether delay from such cause is an unavoidable delay within the meaning of the contract provision above quoted. The decision was against the contractor.

The court in the opinion stated that the delay was one due to the contractor's error of judgment, and that there appeared to be no ground upon which he could ask to be excused from the consequences of his own mistake. The court cited with approval the rule expressed in the case of Chicago, etc., Railway Co. vs. Hoyt (149, U. S., p. 14), which is as follows:

"There can be no question that a party may, by an absolute contract, bind himself or itself to perform things which subsequently become impossible, or pay damages for the non-performance, and such construction is to be put upon an unqualified undertaking where the event which caused the impossibility might have been anticipated and guarded against in the contract, or where the impossibility arises from the act or default of the promisor. But where the event is of such a character that it cannot be reasonably supposed to have been in the contemplation of the contracting parties when the contract was made, they will not be held bound by general words which though large enough to include, were not used with reference to the possibility of the particular contingency which afterwards happens."

The court referred to the fact that the contractor had not given notice in writing of the impending delays, as required by the contract, and the contractor endeavored to plead certain conversations with officials concerning the delay. The court, however, would not hear such plea in the face of a provision in the contract that no verbal statement of any person should be allowed in any manner or degree to modify or otherwise affect the terms of the contract.

This comment may indicate that the contractor might have had a better case if the notices required by the contract had been duly given. Contractors generally may be skeptical as to the soundness of the reasoning which leads to the conclusion that delay in getting material such as structural steel cannot "reasonably be presumed to be beyond the control of the contractor." Every builder knows the absolute uselessness of trying to secure quick deliveries when the mills do not happen to be rolling the desired shapes, and especially under government inspection.

But one has only to remember an ancient maxim of the law—*qui facit per alium, facit per se*—"he who acts through another, acts by himself"—to realize that responsibility cannot be successfully shifted by a principal to his agent. If a sub-contractor fails to make deliveries as required, he may be liable to the contractor; but it is the contractor who is liable to the Government, and the liability cannot be avoided by pleading the sub-contractor's failure.

THE EXCAVATION OF IRON ORE by electric and compressed-air shovels instead of steam shovels is to be experimented with on the Mesaba range in Minnesota, and an electric shovel is now being built by the Bucyrus Co. The purpose is to economize in power production by generating power at one large central plant instead of by a boiler and engine on each of the numerous machines. The electric power would be generated at the new Duluth water-power plant. Experiments are also being made with a cableway of about 1,000 ft. span, handling grab buckets, the cableway traveling over the ore bed as the work progresses.

SOME RECENT EXAMPLES OF THE USE OF GAS AND GASOLINE ENGINES IN MARINE WORK.

The use of gasoline engines to drive screw propellers for auxiliary power on schooners and other sailing vessels has been referred to in our columns, and we have recently obtained particulars as to the equipment of several vessels of diverse types. In many cases the engines are used only in case of adverse winds and to work the vessels in and out of harbor without the expense of towage. In some cases, however, the power is regularly used all the time, as in the schooner "Sotoyome," owned by the Albion Lumber Co., of San Francisco. This vessel is 170 ft. long, 37 ft. beam and 9 ft. 6 ins. deep, of 503 tons, and with a cargo capacity for 750,000 ft. of lumber. It has twin screws, 5 ft. diameter, driven by a pair of three-cylinder engines of 300 HP. each, while a 5-HP. engine drives the electric plant. A somewhat larger schooner, the "Argus," has a similar equipment, but with propellers 5 ft. 6 ins. diameter. The wind is against these vessels in one direction on their trips, but we are informed that since the installation of the engines they nearly always make their trips on schedule time. The engines are fitted to use crude oil or untreated distillate, and each vessel carries about 15,000 gallons of this fuel. The new passenger vessel "Anvil," owned by John J. Sesnon & Co., and running from San Francisco in the Alaska trade, has a similar equipment to the "Sotoyome," together with an 8-HP. engine for the electric light plant and another 8-HP. engine for the hoist and windlass. Still another vessel is the German Government police boat "Ponape," employed in the South Seas; this is a two-masted schooner yacht, equipped with a three-cylinder engine of 125 HP., fitted to use kerosene.

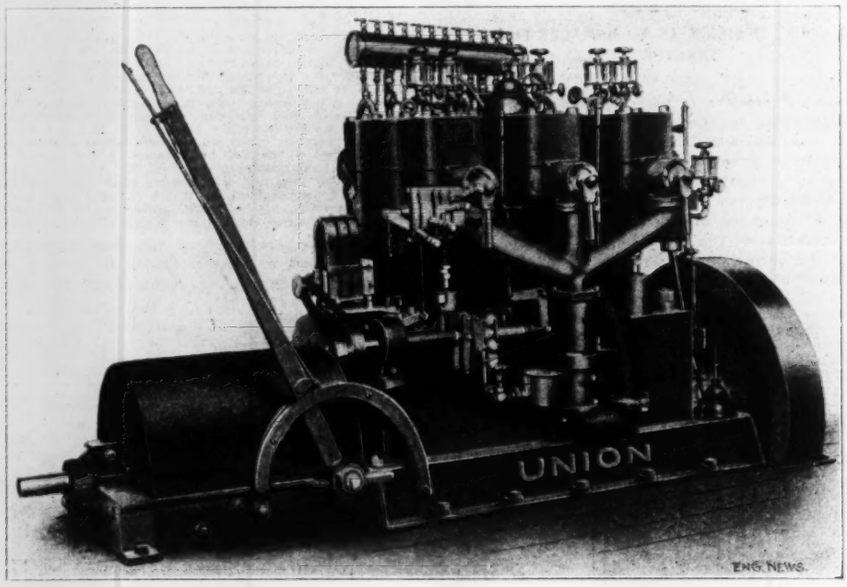


FIG. 1. THREE-CYLINDER MARINE GAS ENGINE OF 300-HP.
Union Gas Engine Co., San Francisco, Cal.

The engines for all these vessels were built by the Union Gas Engine Co., of San Francisco, and one of the three-cylinder 300-HP. engines is shown in Fig. 1. The fuel consumption is said to average 0.1 gallon per HP. per hour. The engine is directly connected to the propeller shaft when going ahead, but drives it by means of bevel gears when reversed. The average speed of the engines is 250 revolutions per minute, giving a speed of between 7 and 8 knots. If necessary, the propeller can be disconnected, so as to revolve idly when the ship is under sail. The engine is made with all its parts readily accessible, and has an automatic vaporizer. When the needle valve is once set, no further adjustment is required for either load or speed. By the special system of control employed the engineman can regulate the speed, ignition, mixture and relief without moving away from the reverse lever.

An interesting experiment in canal-boat propulsion with gasoline engines is being made on the Miami and Erie Canal by the Ohio Boat Co., of Lockland, O., which has several boats in operation. The first boat was started in June, 1904, and has been in service ever since, with the exception of two or three months when the canal was empty on account of a washout. Most of the boats run between Cincinnati and Lockland (12 miles) and Cincinnati and Middletown (42 miles), while one runs as far as Dayton, 65 miles from Cincinnati. The boats are 80 ft. long and 14 ft. wide, with a depth of hold of 4 ft. 6 ins.; the wooden house increases the total headroom from floor to roof to about 8 ft. They are of steel construction, with ribs or frames of Z-bars, but have no keel. The plating is of mild steel, ⅜-in. thick for the bottom and ¼-in. for the sides. The displacement is about 70 tons, while the cargo capacity is 40 to 50 tons. The boats have a draft of 10 or 12 ins. when empty and are loaded to a 3-ft. draft, which is as much as the depth of the canal will permit. They were built by the Stacey Mfg. Co., of Elmwood, O.

Four of the boats are equipped with gasoline engines built by the Clifton Motor Works, of Cincinnati, O. One has a gasoline engine built by Fairbanks, Morse & Co., of Chicago, and another has a Mietz oil engine. The Fairbanks & Morse engine is a two-cylinder engine of 20 HP., and the makers say that the draft of the boat is 2 ft., while the average depth of water is only 2 ft. 9 ins. In consequence of this s... draft, it is often necessary to take off the ... er and remove pieces of barbed wire, carp... d mat- tresses, etc., which became entan... ith the blades. Frequent breakdowns have ... curred owing to sticks, rags and other ref... g car- ried into the cylinder jackets. They ... e that a paddle wheel would be better ... screw propeller under these conditions, and ... the cir- culating water should be passed thro... screen. The oil engine with which one of ... oats is equipped was built by August Mi... of New York, and is a 22-HP. three-cylinder ... e, with cylinders 6 × 6½ ins., running at ab... revo- lutions per minute and driving a ... n. pro- peller. The propeller shaft is driven ... ct when going ahead, and through a train of ... el gears by means of a friction reversing ... ch when going astern. The same builders ... fitted a 30-HP. engine to a dispatch boat of the Merritt & Chapman Derrick & Wrecking Co., plying in New York Harbor, and two 15-HP. engines to fishing and oyster boats. Of course, both gasoline and oil engines are extensively used in yachts, motor boats and other pleasure craft, but these are not considered in this article.

Three of the Clifton gasoline engines are of 21 HP., with three cylinders; the other is a four-cylinder engine of 28 HP. These are all of the marine type, with cylinders 6½ × 7 ins. The engine shaft is 2¼ ins. diameter, and has a heavy 20-in. flywheel to which the governor is fitted. The propeller shaft is 1¾ ins. diameter. The normal speed is 400 revolutions per minute, with a minimum of 100 and a maximum of 600 revolutions. The reversing lever, carburettor and spark lever are placed together, for convenience in handling, but the operator need not touch the carburettor or throttle in manipulating the clutch and reversing gear. The jump-spark type of ignition is used, with contact maker on the cam shaft, and the contact maker can be shifted to various positions for different rates of speed. Auxiliary cams hold the exhaust valves open in starting, after which they are released. When going ahead the engine is directly connected to the propeller shaft by means of a rigid coupling. Reversing is accomplished by a bevel gear with a clutch; the bevel gear has specially planed teeth and is mounted in a cast-iron drum. The propeller revolves in a tunnel or chamber under the boat at about two-thirds of the length from the bow, as shown in Fig. 2. The water is discharged downwards under the center of the boat and scours the mud and silt, keeping the canal clean. There is said to be no washing or scouring of the banks. Each boat carries 150 gallons of gasoline, which is sufficient for several trips. The speed in going up the canal with a regular cargo averages about three or four miles an hour. In coming down the speed runs as high as six miles, although the time lost at locks cuts the average speed to about five miles an hour.

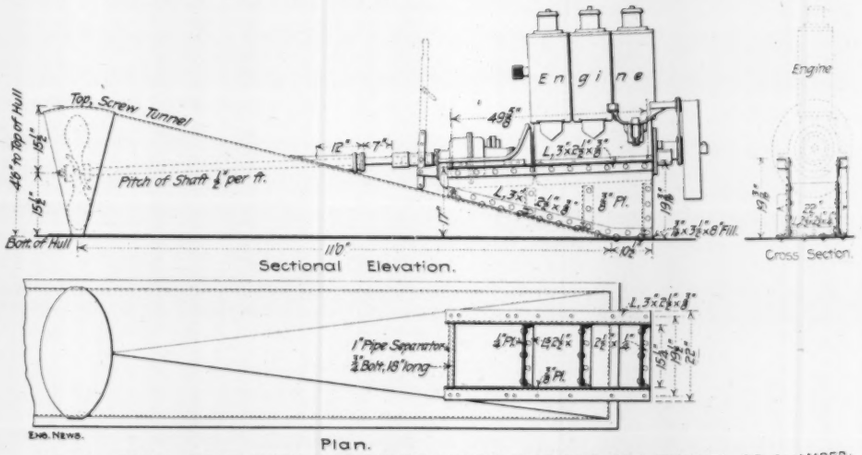


FIG. 2. CANAL BOAT WITH PROPELLER SCREW WORKING IN A TUNNEL OR CHAMBER: MIAMI & ERIE CANAL.

A small torpedo boat for coast and harbor work has been built by Yarrow & Co., of London, England, and fitted with three Napier gasoline en-

gines, driving three screws. The boat is 60 ft. long and 9 ft. beam, with a minimum draft of 12 ins., and has attained a speed of 26.15 knots, or over 30 miles an hour. The two side engines are of 120 H.P. each, and can go ahead only; the central engine is of 60 HP., and can be reversed. There are three speed indicators (one for each shaft), three throttle levers and three control levers, all arranged together for convenience in

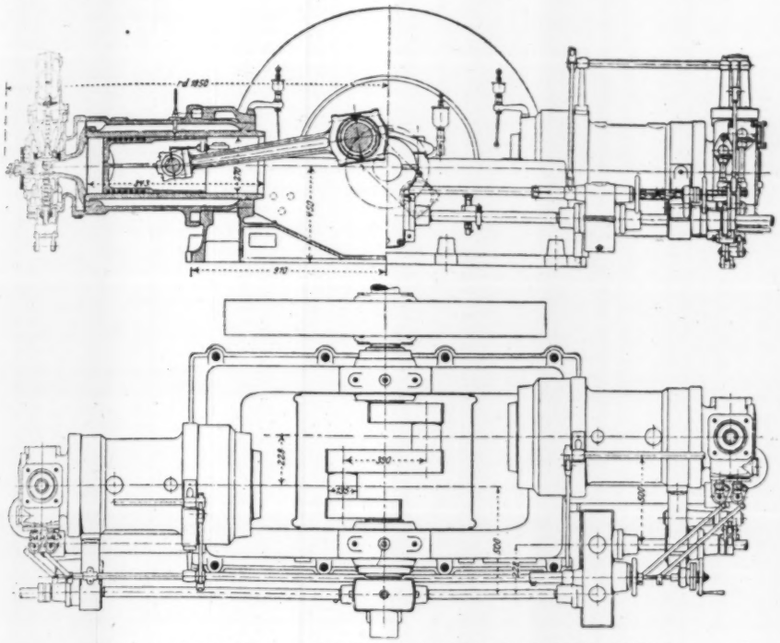


FIG. 3. HORIZONTAL MARINE GAS ENGINE FOR RIVER BARGE.
Otto Gas Engine Co., Deutz, Germany.

handling the boat. To reduce the danger from the gasoline, the storage tank (at the stern) is built separately from the hull, which is so arranged that in case of accident to the tank the gasoline would flow into the sea instead of into the hull.

Perhaps the most interesting example of the application of gas engines to marine propulsion is the equipment of German river barges with gas producers and gas engines, as described in the "Zeitschrift des Vereines Deutscher Ingenieure."

One of the largest examples of the application of suction gas engines to the propulsion of boats for river navigation is furnished by the river boat "Lotte," a flat-bottom barge 139½ ft. long and 15-ft. beam, carrying 240 tons upon a draft of 6½ ft. This was originally intended for service on the Elbe, but has been retained by the builders of the engines, the Otto Gas Engine Co., of Deutz, for their own carrying trade between Cologne, Antwerp and Rotterdam. In order to obtain good balance for the engines, a four-cylinder horizontal arrangement has been adopted. One-half of the engine is shown in Fig. 3. The engine develops a total of 80 to 100 HP., which is sufficient to drive the boat about 3½ miles an hour against the current in the river. A sectional elevation of the boat is shown in Fig. 4. The screw shaft is connected with the engines by a friction coupling. The gas producer is placed in front of the engine-room, from which it is separated by a bulkhead with sliding doors, which can be closed during the operation of cleaning the grate from ash and clinker. The screw is 4 ft. 3 ins. diameter, and is fitted with four blades reversible in direction by a rack and pinion motion; the reversing rod ends in a series of toothed racks which gear into corresponding pinions on the axes of the reversible propeller blades. The power required for reversing is taken from the main engine shaft by a combination including a friction coupling, differential gear wheels, and toothed clutches and helical gears, which screw the rod backwards and forwards. This is brought into action by throwing the clutch into the back or forward gear as required when starting it by the frictional coupling with the main engine. The motion necessary for any required pitch is marked on a divided scale and this is varied according to the action of the engine, the pitch being gradually increased until the full load is attained.

For starting, as well as for working the fan blower or the cargo winch on deck, a small benzine engine of 6 HP. is provided, which starts the main engine by a frictional connection with the fly-wheel and keeps it running until ignition in the cylinder has commenced. When the engines have been standing for a long time the fan blower is used for a few minutes to increase the combustion in the producer. This, as well as the deck winch, is driven by a belt and a line of overhead shafting.

Up to the present time 11 different boats with suction gas plants have been built by the Deutz Co., the horizontal arrangement being used for the larger sizes, with two cylinders up to 45 HP. and four cylinders for 65 to 90 HP.; the latter run at 275 to 325 revolutions per minute. For smaller boats the ordinary vertical marine type of engine is used, with two, three or four cylinders, using mineral oil or alcohol as fuel. Boats of smaller power are largely used in Holland, and it is said that 280 of these, together developing 2,500 HP., have been supplied to that country by this firm, out of a total of 320, with 4,000 HP. of engines.

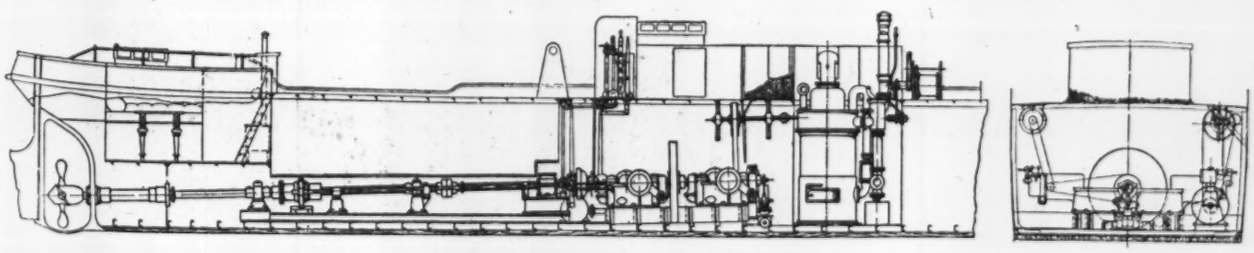


FIG. 4. SECTIONAL ELEVATION OF GERMAN RIVER BARGE WITH GAS ENGINE AND PRODUCER PLANT.

Cargo boats of the kind described above have been found to be extremely economical in working. The following results having been attained in the Rhine navigation between Cologne and Rotterdam, a distance of about 190 miles. With a boat of 250 tons carrying capacity, with an average load of 200 tons and engines of 100 HP., costing about $11,250, the average time required for the round trip, inclusive of all stoppages, is 14 days, thus giving 26 voyages in the year.

Depreciation on hull, 5% on $5,000	$250
Depreciation on engines, 10% on $6,250	625
Interest on capital, 5% on $11,250	562
Insurance, 4%	10
Navigation dues, 26 trips, at $37.50	975
Fuel (anthracite at $5 per ton), burnt at the rate of 1.32 lbs. per HP.-hour for 75 hours per round trip, 50 hours upstream and 25 hours downstream—117 tons	585
Oil and waste	243
Wages	1,750
Total annual outlay	$5,000

The cargo carried was 200 × 26 = 5,200 tons for a distance of 375 miles, or 1,950,000 ton-miles, corresponding to a cost of 0.0617 ct. per ton-mile. The corresponding cost of carriage by the ordinary river steamboats is about 50% more; on the lowest railway freight about five times as much. On the Saarbrucken Mullhausen Canal, where the round trip of 170 miles required 30 days, including 9 days' detention and 9 days' returning light, the cost, with the gas engine in a boat of 240 tons, with a 16-HP. engine, was only two-thirds of that of horse traction, the boat making eleven journeys in the year by the former as compared with seven by the latter method.

The revival of inland navigation in England has also been attended by experiments with gas engine propulsion, and a propeller barge, fitted by John I. Thornycroft & Co., of London, with the Capitaine marine gas engine and suction gas producer, has recently made a tour of the canal system. Fig. 5 shows this equipment. The following description of the mechanical equipment is taken from an English paper:

The engine is of the vertical enclosed type, fitted with two cylinders, each 8¼ × 11 ins., and runs at 300 r. p. m., giving about 38 brake-HP. The inlet and exhaust valves are all mechanically operated, the cam-shaft being placed above the top of the cylinders and slightly out of the center line, and the valves being actuated by means of rocking levers. The cam-shaft is hollow, and carries in it a sliding shaft which, by means of radial arms projecting through slots in the cam-shaft, operates the low-tension ignition strikers. The longitudinal motion of this inside shaft is controlled by the governor of the engine, and varies the time of ignition, advancing it as the speed of the engine increases. An arrangement is made whereby the timing of the magneto machine is simultaneously varied to correspond with the point of ignition. The engine itself is controlled by means of a throttle valve in the induction pipe connected by a special device to the governor. Half-compression gear is provided for starting the engine, which is done by a separate 6-HP. engine through the medium of a belt. The half-compression cams are automatically thrown out of action by means of an attachment to the governor, when the engine is running at normal speed. A centrifugal pump, driven by the engine, is provided for supplying cooling water to the combustion heads and cylinder jackets. The exhaust is water-jacketed, and the gases are discharged up a chimney, no silencer being required. The gas producer is of the ordinary cylindrical shape, lined with fire-brick, and has three charging doors in the top, which deliver into a conical annular hopper. The gas producer plant provides, moreover, for drying and purifying the gas without using any solid material in the scrubber, as is usual.

Mr. Emil Capitaine, of Frankfort-on-Main, Germany, inventor of the Capitaine system, states that the Scotch type of marine boilers requires about 14 cu. ft. and weighs 220 lbs. per cu. ft. (including water) per HP.; for water-tube boilers the figures are 5.3 cu. ft. and 51 lbs., while for gas-producers the figures are 1.75 cu. ft. and 51 lbs. These figures are exclusive of the condenser plant for the boilers, and the water purifying and steam generating plant for the producer. He has designed marine plants for large power, and his engine of 80 HP. has four single-acting four-cycle cylinders, and runs at about 320 revolutions per minute. Each cylinder, with its valves and mechanism, is a complete and independent unit. In order to combine rigidity with light weight,

the frames are built of steel plates and angles. To start the engine a small gasoline motor is provided, but this is only required to work for a few minutes each day. Wm. Beardmore & Co., of Glasgow (Scotland) and John I. Thornycroft & Co., of London (England), have commenced the construction of a Capitaine four-cylinder marine gas engine of 600 HP., which, by the addition of two cylinders, may be brought up to 900 HP., or practically equivalent to a steam engine of 1,000 HP. One of these large engines under construction is shown in Fig. 6. The Capitaine system is to be introduced in the United States by a company located at 25 Whitehall St., New York City. We quote the following from a paper by Mr. Capitaine:

The marine gas engine in its smaller sizes has a higher thermal efficiency than the steam engine, and though the price of anthracite and coke for the producer averages 50% higher than steam coals, there is still an economical advantage, as the cost of fuel for a gas engine of 100 HP. is less than 50% of that for a steam engine of the same power. With larger gas engines this economy grows smaller compared to the steam engine, and the limit is reached at the point, where instead of anthracite and coke, the cheaper coal may be used. Here the economy increases again, up to about 1,000 HP., where it becomes somewhat less, as a result of difficulties particular to marine service. The economy of weight and space remains up to 1,000 HP. decidedly in favor of the gas engine compared to a modern steam engine.

One of the most serious difficulties of the gas engine for marine purposes is the incapability of reversal. Gasoline engines for boat use have been reversed by application of compressed air. A reliable reversing motion demands machinery, too complex for smaller plants. For engines up to 200 HP. the propeller with reversible blades seems most suitable because it permits a regulation of speed or immediate reversal in a very simple manner. The objection of slight durability against these propellers, as compared with solid ones, is unfounded, according to my experience. In the Meissner design the blades have a very solid bearing in the hub, and the mechanism of their movement is as simple as conceivable If a blade should be broken off, the hub would not be injured, and a new blade could be inserted with facility. Whether the propeller can attain the efficiency of the solid propeller, must be left for future practical demonstration. In place of the reversible propeller, a reversing gear may be used. This reversing gear has the advantage of small dimensions and great durability; besides, it permits of one-third speed reduction, running astern. If the propeller works backward with the same speed as forward, the motor can often not attain its normal revolutions, owing to increased friction, and may stop altogether if one of the cylinders should give out on account of a failing explosion. The engines of small boats have to be reversed often, and therefore absolute safety is more essential than with larger ships.

The nature of the modern gas engine requires that with reduced speed, the work of each power stroke be more and more reduced, contrary to steam engine practice, where by means of a late cut-off a resistance even higher than the normal may be overcome. For marine gas engines of over 200 HP. neither an adjustable propeller nor a reversing gear seems in place. Compressed air only can be used, which motion reverses the direction of the engine shaft.

The conditions laid down for a high-power marine gas engine are principally quiet, steady motion and speed reduction, with immediate reversion at will. Of course this gas engine should also use a considerably smaller amount of heat, as otherwise there would be no need for a removal of the steam engine.

A VERY LARGE HIGH-HEAD TURBINE has been ordered of the Allis-Chalmers Co., Milwaukee, Wis., by the California Gas & Electric Corporation, for a power plant at Chico, Cal. The turbine is a single horizontal spiral-case reaction wheel of 9,700 HP.; it will operate at 400 r. p. m., under 550 ft. head.

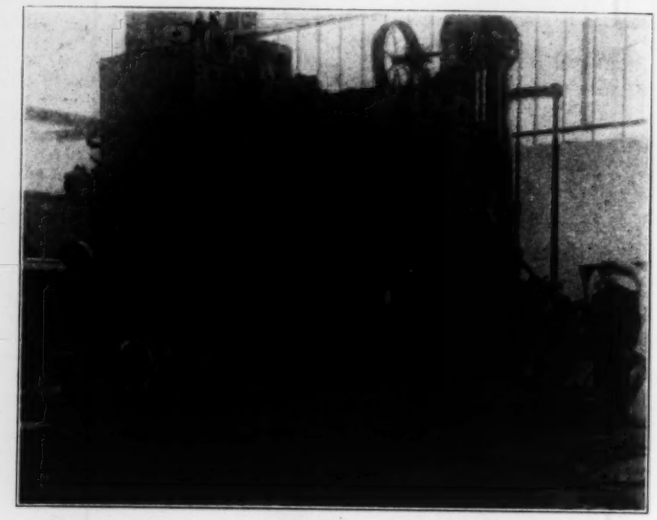


FIG. 5. THE CAPITAINE MARINE GAS ENGINE AND PRODUCER PLANT FOR TUG-BOATS AND YACHTS.

SHOP HINTS FOR STRUCTURAL DRAFTSMEN.*

(With two-page plate.)

By John C. Moses,† M. Am. Soc. C. E.

I.—The Draftsman and the Templet Maker.

The manufacture of structural steel work may be divided into the four operations of drafting, templet making, shop work and erection. The draftsman's portion consists in making drawings in accordance with the designs of the engineer for the guidance of the workmen in the remaining operations. As the engineer's designs are frequently incomplete it may also be part of the draftsman's duties to design details of joints, rivet spacing, etc. This part of his work is frequently described and will not be here dwelt on. We wish rather to consider his work as part of the process of manufacture after the design is complete.

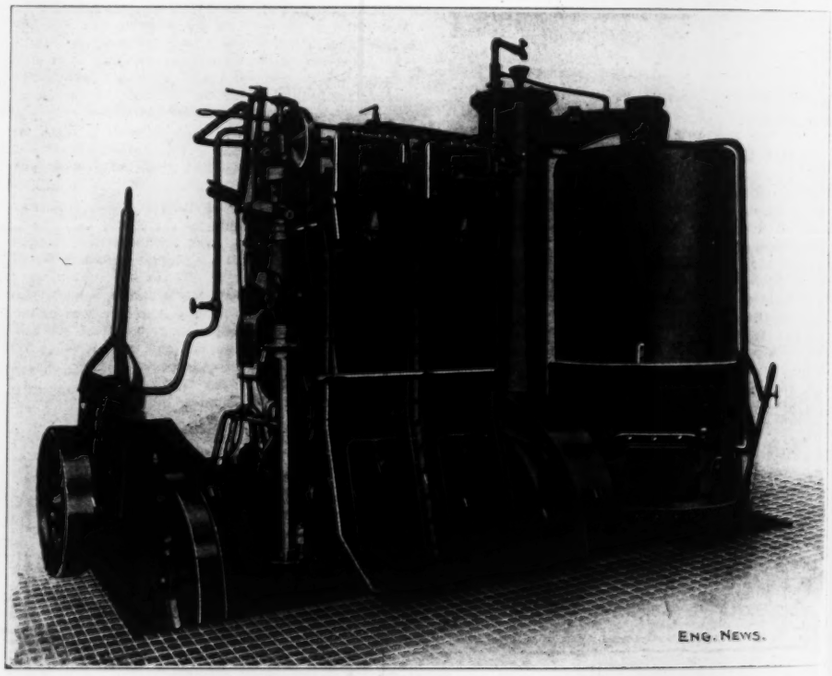


FIG. 6. A LARGE CAPITAINE MARINE GAS ENGINE.
Built by Wm. Beardmore & Co., Ltd., Glasgow, Scotland.

This subject is of growing importance. Drafting offices at the present day are not in as close touch with the shops as formerly and most draftsmen have little personal knowledge [illegible] operations. As a result drawings frequently call for details that could easily have been simplified as to reduce shop costs; but when these drawings reach the shop they have been checked and approved and it is a troublesome matter to make any changes in them. The badly placed rivets are driven by hand, two sets of templets are made where one might have done, the detailer cuts off his gussets to get in his [illegible], etc. Each one has his opinion of the draftsman, but the culprit is not there to see or hear and the matter is not important enough to send a busy foreman to enter a formal complaint. The draftsman keeps on copying the same detail for subsequent jobs, and in the aggregate the increase in cost is considerable.

Further, the cost of drawings is to-day a larger part of the total cost of manufacture than it used to be. The draftsman must justify this by making possible a decrease in the other shop operations sufficient to make a reduction in the total cost of manufacture. This requires an understanding of the operations subsequent to his own.

The writer hopes that the hints here given will be useful not only to the draftsmen employed in structural shops, but also to those elsewhere employed, for economy of production is one of the essentials of good engineering.

We will consider first the templet shop and see what the draftsman can do to save expense in that department while still conforming to the engineer's requirements. He should realize first of all that the cost of the templet department is about two-thirds that of the drafting department, and that the two combined may spend as much on a job as is spent in the actual construction in the shop. Any reduction of expense in the templet shop therefore is decidedly worth while.

It takes about as much time to make the templets for a job as it does to make the drawings. The drafting department, however, generally uses up most of the available time and so the templet foreman must put a number of men on the job at once. Therefore each drawing should be made complete in itself. If two or more sheets can best be laid out by one templet-maker a note on each sheet must say so. The shop bills must be separate for each sheet. General notes giving size of rivets, reaming directions, etc., must appear on each sheet. Identical pieces ap-

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†Engineer of Construction, The Boston Bridge Works, Inc., Boston, Mass.

pearing on different sheets may be given the same name and be referred to on all the corresponding shop bills but one as "old templet, page ——"; when so noted they are passed over by the templet maker and are made by the man having the page not so marked. But all the dimensions must be given on each sheet to enable the connecting parts to be made without looking up any other drawing. When the templets are checked such a one is filed in each place it is to go and the total number wanted placed upon it.

But if the bill is put into the shop piecemeal, so that punching will begin before the templets are done, it is often best to name the pieces on each drawing as if they did not appear elsewhere; it will be easier to make the templet over again than to get back the former one and check the new work with it. This case frequently happens in building work. Pieces should not be named alike when this is done, for templet checkers pass a shop-driven stiffener, for instance, if it matches its girder web, and do not try the actual spacing. The templet maker lays out a spacing once and then transfers the marks to the connecting pieces, and so may have them match, although not like the drawing. If the piece appears on another drawing without being noted as an "old templet" it may be made a little differently the second time and not detected. In the shop the stiffeners that match one girder may be put on another web, with poor results.

When parts can not be made identical it is desirable to draw them so that several can be placed on one templet. This saves lumber, which is expensive, and takes time to prepare; it saves time in making the templets; and it makes less templets to handle in the shop or to store. The similar pieces should be drawn on one sheet; frequently they are represented by one drawing, with notes corresponding to those the templet-maker will use on his templet. In the latter case, do not note a detail as "Omitted on Col. 3 only," but note it thus: "On Cols. 1, 2, 4 and 5." The templet-maker will surround the holes on his templet with a ring containing the numbers 1, 2, 4, 5, and he wants *positive* orders, not negative ones, on his drawing. If similar pieces differ in length by a few inches, throw all the difference into one end, if possible, or else into the two ends, but not into the middle. Then most of the templet holes will be alike for both kinds of pieces. Arrange the holes that are not alike so that they will be at least ⅜-in. apart on the templet; then they can be bored without splitting out the wood between the holes.

Make rivets in girder flanges opposite, and not staggered, if the engineer will allow it. The theoretical advantage of staggering rivets in the two legs of wide angles is, to say the least, problematical, while there is a distinct advantage in placing the rivet on the wide gage of one leg opposite that on the narrow gage of the other leg, since in this case one hole in the templet marks both rivet holes. It should be said, however, that where angles are thick or gages narrow, staggering the rivets makes it easier to drive them; this point is considered much more important in some shops than in others.

In making templets for plate girders a board is first laid off to represent one leg of a flange angle. All odd holes in either leg of any flange angle are included. Four similar boards are clamped under this one, and then all five are bored at once. Two of them are battened together for the flange plate pattern, and the other two form the top and bottom of the web plate pattern. Similarly a stiffener or web-plate splice is laid out, and with it are bored pieces for the web templet. In order to make this method of templet-making applicable to cambered girders, the camber is produced by making one corner of each web section slightly less than a right angle, keeping top and bottom flanges alike.

For beam work use standard details as far as possible. Boards just large enough to contain the group of holes for each standard connection are kept at the marker's bench, and the beam templet consists of a pole with center lines and names of connections. This pole is laid on the beam, and the connection templets are moved to the proper mark and set at the proper height by gages that hook over the top of the beam and drop into holes in the boards.

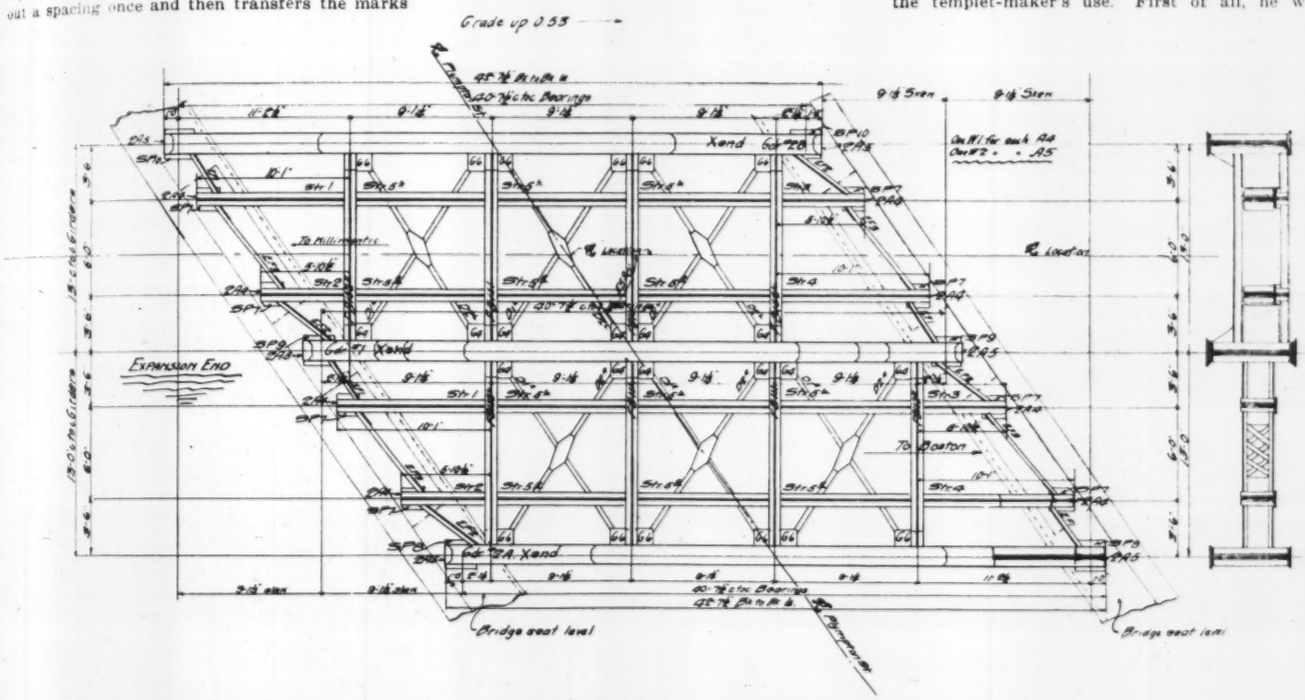
Pole templets are strips of wood about 1¼ ins. wide by ½-in. thick, planed on all four sides, and of any desired length. They are also used for angles having single-gage lines, the holes being located by lines drawn across the pole. One side of the pole gives the holes in one leg of the angle and the other side gives the marks for the other leg. When marking the steel the pole is placed alongside the angle, or between two angles, if a right and left pair are wanted, and lines drawn square across the leg of the angle by means of a small try-square. The gage of the holes is determined by a gage on the machine. Pole templets are quickly made, contain little lumber, and can be used several times by planing out the old marks.

Webs of similar truss posts or diagonals can often be made alike when their flanges are different. Templets for such webs are made of two narrow boards battened together. If alike except for distance apart transversely of holes, the boards can be bored from one lay-out and set the proper distance apart when battened together. A small and a large gusset will go on one templet if the holes in one will match the holes in the other as far as they go. It is sometimes advisable to vary the gages in angles from the standard in order to make tie plates and lattice alike.

In planning pieces to go on the same templet it should be remembered that it is not usually best to make templets with detachable ends to be changed for different pieces, or to make them in half lengths to turn over. Templets are made of narrow boards battened together and cannot be turned over to advantage, and detachable parts are apt to be inaccurately matched to the main templet when marking the steel.

The dimensions on drawings are primarily for the templet-maker's use. First of all, he will want to set his helper to work to get out the lumber. For that purpose the drawings should state the length and width of all gussets and lengths of all other pieces. Web splices of girders should be located on a separate dimension line. Locate all web stiffeners similarly, also ends of flange plates. Tie in rivet spacing with other dimension lines at every opportunity. A templet-maker lays out rivet spacing by stretching a tape, usually divided to eighths, beside his board. If he comes out wrong at the end of a long line he has to go all over it again, erasing his old marks; it will save him much time to have his spacing tied in at every stiffener, web splice and flange plate end. He works with a soft pencil on soft wood, and sixteenths make pretty fine work, to be avoided as much as possible. When a number of equal spaces are used, always give the total they make up. Unfortunately, templet-makers can rarely be brought to see the use of doing anything twice by different methods as a check; rivet spacing on drawings should therefore be checked with general dimensions.

The shop bills should be carefully checked in the drafting-room, for a templet-maker may copy the number of pieces there called for, regardless of the drawing. Write "exact" after dimensions that must not be exceeded. Give the total distance between holes in the outstanding legs of end connection angles, but also give gages in every case for the templet-maker. Note when



ERECTION PLAN OF A PLATE GIRDER BRIDGE. (SEE INSET SHEET FOR DETAILS.)

uprights, fillers or splice battens must be fitted to flange angles. Avoid double cuts on one leg of an angle, as they involve making a special cutting pattern to go with the templet pole.

When showing only part of a given piece, always draw the *left-hand end* of the piece, as the templet-maker must work from left to right with

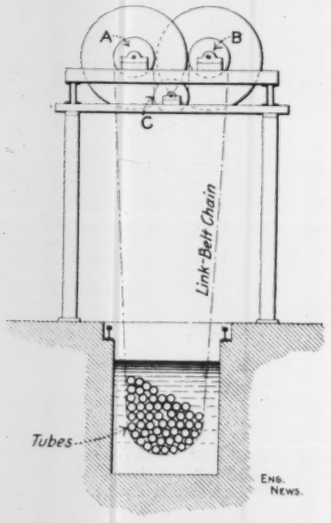


Fig. 1. Machine for Cleaning Locomotive Boiler Tubes.

his tape. Use uniform methods, putting general notes in the same part of all drawings, and writing sizes of stock in the same way every time, and on the left ends of the pieces. Do not change existing customs without exceptionally good reasons. Uniformity of drawings not only saves much time when looking for information in the shop, but also much liability of mistake from oversight. In general, remember that the templet-maker has to redraw everything and should have dimensions given so as to make it easy to do this.

There are many advantages in laying out work full size on a floor in the templet shop. Truss members and connecting gussets are then checked as to length of pieces and matching of holes, and interferences are detected. When this is customary the drawings can be simplified to great advantage and at the same time lessen the work of the templet-maker, who is no longer obliged to follow exact spacings. Many connections can be laid out by him as well as by the draftsman, thus saving the draftsman's time. A disadvantage of this method is the impossibility of dividing the templet work among as many men; another is the lack of the kind of men formerly found in templet shops.

PATTERN MAKING.—Most of this work will consist of shoe plates or machinery for drawbridges. This work is expensive and can often be simplified by making patterns that are altered to make the different castings by means of detachable pieces. Old patterns can often be used again, with perhaps some changes. As usually but one or two pieces of a kind are wanted, it is often cheaper to use an old pattern that is heavier than needed, the cost of a new pattern being more than the value of the iron saved. Cores are expensive to make, and, as shoe plates are designed for bearing values of masonry, the top surface can be ribbed to save metal instead of coring out the inside. Straight surfaces are much cheaper than curved ones, which latter must often be whittled out by hand.

The cost of the pattern rather than the amount of iron is usually the determining factor when there are but few pieces of a kind. The reverse is true when there are many of a kind, and a little calculation of weights and costs will often determine the best thing to do.

Make casting drawings to scale correctly and to a larger scale than is usually used for the other drawings. Draw them on separate sheets, as they go to the pattern-maker, while the other drawings go to the templet-maker. Note if holes are to be cored or drilled. If the latter, a templet will be made by which to lay out the holes, as on other pieces of iron. Cored holes are likely to be irregular in size and incorrectly located, and should not be used for machinery connections. Always note all surfaces that require planing, as an additional thickness of pattern is there required. A pattern-maker can do almost anything when necessary, but very slight modifications in design will frequently cut the cost in half.

ILLUSTRATIVE EXAMPLE.—As an illustration of some of these hints, the reader is referred to the accompanying drawings (see the inset sheet of this issue, and the erection plan on p. 327), showing details of a skew plate girder bridge having a heavy center girder and two lighter outside girders.

Examination of the details will show that all the web templets can be placed on one templet, although the two ends of the light girders are not alike, and the heavy girder has four lines of web holes for each flange in place of two for the light girder. One thing done to accomplish this was to change the end pitch of the light girder from the 2¾-ins. specified by the engineer to 2½-ins., as called for on the heavy girder, it being considered cheaper to drive the few extra rivets required than to make extra templets.

The flange plates are made with lengths to suit the rivet spacing. Those for the heavy girder have rivets farther apart transversely, but this is done by using the templets bored with the flange angle templet, properly spreading them apart when they are battened together. Stiffeners and fillers are spaced to suit the eight lines of flange rivets of the heavy girder. Rivets in the two legs of a flange angle are placed opposite each other, except where the floor-beam connection requires a different arrangement. The rivet pitch is tied in with the other dimensions, and where a space in sixteenths is necessary it is closely followed by another space with sixteenths that will bring back the total to larger fractions.

The lateral bracing angles are connected with the stringers, but as this bracing will be made on the floor, it is not fully dimensioned, and the stringer holes are left to be determined from the layout. All the stringers will go on one set of templets.

The floor beams are made with all end pieces alike, the difference in length of the two halves being put into the main web and flange angles. As these will be made full length in any case, this is the best place for the variation. Skews for the end frames are given by the original figures. This method involves less risk of mistakes in figuring and is easy to check. If it is acceptable to the templet maker it is the best way.

The draftsman will find that it takes very little extra time to make drawings in this way and that it will make his work much more interesting to himself as well as more profitable to his employers.

In a subsequent article the writer will consider some of the features of shop operations that should be understood by the draftsman.

TUBE CLEANING MACHINE FOR RAILW[AY]

A tube rattler of special design f[or] economical work with a minimum noise is now in use at some large rail[way] tive shops, and its general feature[s] in Fig. 1, while Fig. 2 shows the [ma]stalled at the new Montreal shops of t[he] Pacific Ry. The rattling or cleaning [is] tank of water, which reduces the no[ise] pared with that of a rattling drum o[r] over this tank is erected a steel fra[me] the driving mechanism. On this fra[me] sets of sprocket wheels, each consist[ing] wheels, A, B, C; one of these sets is [on] a traveling trolley, so that the distan[ce] the two sets can be varied to suit th[e] tubes to be cleaned. Each set of wh[eels] a continuous link-belt chain, which p[asses] the wheels A and B and under the idler wheel C. The wheel A is driven from an electric motor and drives the chain.

The tubes to be cleaned (about [fo]ur at a time) hang in the loops of the two chains and are rapidly revolved and rolled against each other by the action of the chains; in this way the scale is broken and detached from the exterior, while at the same time the soot and dirt is washed from the interior of the tubes. The speed of the chain is about 130 ft. per minute. Loose bulkheads are placed in the tank to prevent longitudinal motion of the tubes, being adjusted to fit the length of tubes. When the operation is completed a brake is applied to the wheel B, and the wheel A then winds in the chain, so as to raise the tubes out of the tanks and clear of the floor; a push car is then run under the tubes and they are lowered onto the car.

This machine is the invention of Mr. Geo. R. Henderson, Consulting Mechanical Engineer, of New York, who first introduced it in the Topeka

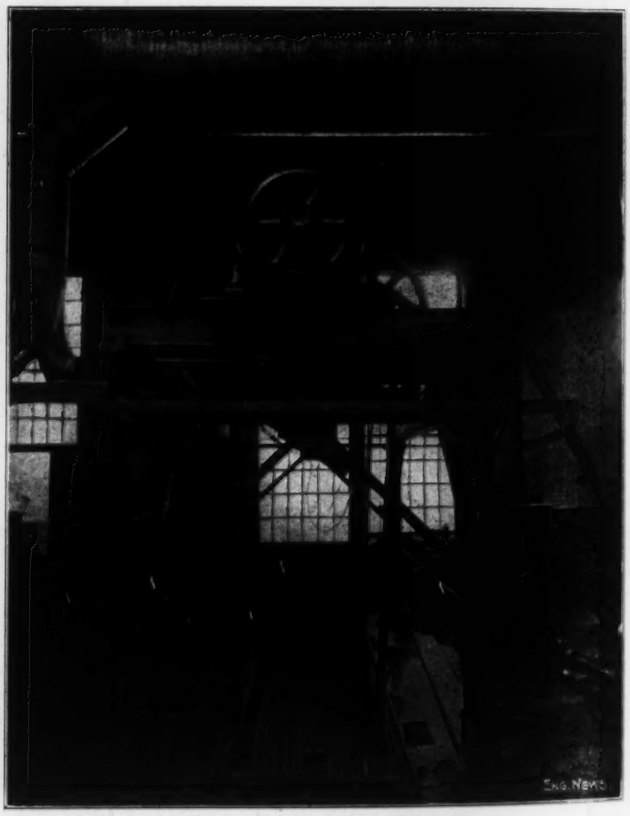


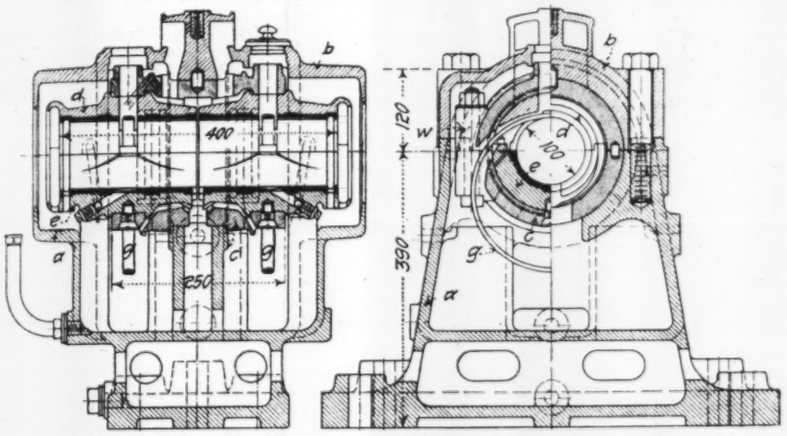
FIG. 2. TUBE-CLEANING MACHINE AT THE MONTREAL SHOPS OF THE CANADIAN PACIFIC RY.

shops of the Atchison, Topeka & Santa Fe Ry. when he was Superintendent of Motive Power of that road two years ago. It is now being handled commercially by Joseph T. Ryerson & Son, of Chicago, Ill.

A SUBDIVIDED SELF-ALIGNING BEARING FOR HIGH-SPEED WORK.

A subdivided bearing of interesting design is shown in the accompanying sectional drawings, taken from an article by F. Niethammer [Zeitschr. d. Ver. Deutscher Ingenieure, Feb. 10, 1906]. It is intended for high-speed work, where journals of great length and small diameter are required in order to provide sufficient bearing surface without excessive surface speed.

The bearing shown was applied to a steam-turbine alternator unit of 500 KVA. capacity running at 2,000 r. p. m., built by the Alioth Electric Company, of Basil, Switzerland. The journal is, approximately, 4 × 16 ins., and thus has the very high surface speed of 2,200 ft. per min. The unusual ratio of length can therefore not be reduced, and at the same time a uniform distribution of loading on the journal becomes essential



A SUBDIVIDED SELF-ALIGNING BEARING, AS USED IN A 500-KW. STEAM-TURBINE ALTERNATOR RUNNING AT 2,000 R. P. M.
Built by Alioth Electric Co., Basel, Switzerland.

to permit cool running. To promote this latter object the designer has subdivided the bearing into two (longitudinal) halves, independently self-aligning, and connected with an equalizer lever to ensure that each receives an exact half of the total load. By virtue of this construction the bearing is required only to meet the conditions which govern the operation of a 4 × 8-in. bearing, instead of those affecting a bearing 16 ins. long, which are probably four times as severe.

In the drawings the letters e-e represent the bearing shells, and d-d their caps, lined with babbit. These shells rest in narrow cylindrical seats formed in the sleeve c, which is carried at its center in a ring-shaped seat in the main pedestal casting and cap, a and b. The sleeve c thus forms an equalizer lever, distributing the load equally between the two bearing shells. The sleeve is split in the horizontal plane, and the two parts are held together by four bolts, as shown at the left in the transverse section. Loose-fitting dowels are provided in the several seats to prevent longitudinal displacement of the bearing shells in the sleeve, or of the latter in the pedestal. The bearing is lubricated by two oiling rings (each made in two halves screwed together) and by pressure lubrication supplied through a separate pipe to each shell from an air-chamber reservoir mounted on the side of the bearing (but not shown in the drawings). A baffle-plate w at the joint between main cap and pedestal, opposite each oiling ring, prevents the leakage of oil through the joint.

The ring oiling provided in this design is stated to give adequate lubrication for surface speeds up to about 2,000 ft. per min. With a surface speed of 2,550 ft. per min., the bearing when using pressure lubrication at 1.5 atmospheres, consumes about 1-5 gallon of oil per minute. For speeds exceeding 2,800 ft. per min. these bearings are water-cooled by a coil of pipe placed in the oil-pocket of the pedestal.

COMPETITION BETWEEN WATER AND RAILWAY TRANSPORTATION LINES IN THE UNITED STATES.*

By Frank Haigh Dixon.†

LAKE TRANSPORTATION.

The geographical situation of the Great Lakes, which touch the richest traffic sections of the United States, invading the agricultural lands and the mining regions of the Northwest, and reaching almost into the manufacturing centers of the East, gives them the possibilities of an immense traffic.

The mechanism of lake transportation consists of steamers and sailing vessels as on the ocean. A rapid increase in the size of steamers has taken place in recent years until we now have vessels many of them as large as the ocean tramps. A change in material of construction from wood to steel has accompanied increase in size in order to provide the increased strength necessarily demanded by the larger vessel operated by steam.

As on the ocean, so on the lakes, the steamers have driven out the sailing vessel, but more rapidly, because of the greater danger to sailing vessels from lake storms, and because good steaming coal being found in lake ports at a moderate price, the steamers are not obliged to waste cargo space in carrying a large supply of fuel. These vessels with their great capacity and high speed are not only ending the usefulness of sailing vessels on the lakes, but are even checking the growth of the towing business, and are likely at no distant day to destroy it altogether.

No description of mechanism would be complete that omitted to mention the instrumentalities at the ports which have increased so enormously the efficiency of lake carriers. The huge docks, with their loading spouts, hoisting machinery, car-dumping machines and ingenious devices of all kinds, have reduced to a minimum the amount of time lost by vessels in port, and as operating expense is nearly as great while vessels are lying alongside, as when in motion, the importance of quick loading and unloading as a means of reducing operating cost becomes apparent.

The characteristics of this lake commerce may be quickly noted. In the first place, it is of enormous volume, the traffic passing through the American and Canadian "Soo" canals in 1904 being 31,546,000 tons, and the total traffic of the lakes being over fifty million tons. This traffic has grown from a paltry 100,000 tons fifty years ago.

In the second place, the traffic is simple in character. Of the east-bound tonnage through the "Soo" in 1904, 98.9% consisted of grain, flour, iron ore, and lumber, and of the total west-bound tonnage 84% was coal. This makes the problem of providing traffic facilities a comparatively simple one, and opens the way to extensive specialization, which means lower operating cost and a possibility of lower rates. About twenty million tons of iron ore are now carried from the Lake Superior ports each season, nearly two-thirds of the country's total production. The ranges of iron mines are distributed along the south shore of the lake and to the north and west, and the ore, handled with the most approved machinery in the least expensive manner, is hauled mainly to six shipping ports, Escanaba, Marquette, Ashland, Two Harbors, Superior and Duluth, and from there distributed, seventeen-twentieths of it, to ten Lake Erie ports, Toledo, Sandusky, Lorain, Cleveland, Fairport, Ashtabula, Conneaut, Erie, Buffalo and North Tonawanda. Nearly two-thirds of this went in 1904 to Cleveland, Ashtabula and Conneaut. The only other important port on the lakes for the receipt of iron ore is Chicago. Wheat is shipped mainly from Duluth and Superior, Chicago and Milwaukee, flour from these four ports and to some extent from less important ports, such as Gladstone, Manistique and Manitowoc. Much the larger part of the grain and flour is received at Buffalo, the next port in importance being Erie, where a small portion is diverted to the railroads and carried to the South Atlantic ports for export. Rates are lower from Chicago than from Duluth because of greater rail competition, the average rate for 1904 from Duluth being 1.8 cts. a bushel, from Chicago, 1.6 cts. In 1904, the total grain and flour received at Buffalo counting four and one-half bushels of wheat as equivalent to one barrel of flour, was 103,000,000 bushels. Some of the other grains shipped by lake exceed in quantity the wheat handled; 39,000,000 bushels of corn were shipped in 1904 almost entirely from Chicago; 32,000,000 bushels of oats and 19,000,000 bushels of barley were handled by water from a large number of ports. Buffalo was the destination for almost all the shipments of these three grains.

Coal for the entire section about the upper lakes and the northwest comes from Pennsylvania, West Virginia, Ohio, Indiana and Illinois. The extent to which this business is handled by water depends upon the desire of the railroads for the traffic as expressed in attractive rates. Fully nine-tenths of the anthracite lake shipments are handled through Buffalo, the only other port of any importance being Erie. Lake Erie ports handle bituminous coal, about three-fifths being shipped from the three ports of Ashtabula, Cleveland and Toledo. Because of competition for return cargo, coal is taken by Lake Superior ore boats at little if anything above the cost of carriage, while fair rates may be charged on coal to Chicago and Milwaukee to which fewer boats go. For example, the average hard coal rate for 1904 from Buffalo to Chicago was 43.4 cts per ton, to Duluth 33.9 cts., the distance being practically the same. The soft coal rate from Ohio ports to Milwaukee in 1904 (none is sent to Chicago), was 47.4 cts. per ton, to Duluth, 37.1 cts.

The third characteristic of lake commerce is the preponderance of east-bound over west-bound business. Thus the problem of empties with which the railroads are compelled to wrestle, troubles the lake carrier also and obliges many of the vessels to return west in ballast.

In the fourth place, lake commerce is practically all through traffic. A certain amount of port to port traffic takes place on Michigan and Erie, but the most important part of the Michigan local traffic is across the lake and is simply a continuation of the rail journey on car ferries. On Lake Erie, a package and passenger business has developed from Detroit to Cleveland and Buffalo. These local lines formerly competed with railroads, but they are now either owned by or operated in connection with railroad systems, and act as their collectors and distributors. But the main lake movements are of much greater length, originating in the upper lake ports, and terminating beyond the St. Clair river at Detroit, Toledo, Cleveland, Ashtabula, Conneaut, Erie and Buffalo. The average length of carriage of thirty-five million tons of freight in 1903 was 835.6 miles; 83% of the east-bound tonnage of Lake Superior went to Lake Erie and beyond, and 95% of the west-bound tonnage destined for Lake Superior ports originated on Lakes Erie and Ontario.

Finally the business of lake transportation is characterized by consolidated control, which is much more effective than on the ocean because of the smaller area, the identity of ownership of railroads, manufacturing plants and lake vessels, and the absence of any large miscellaneous traffic which would attract competition. The smaller fleets, and particularly the towage companies, have been bought up and operated by large companies.

Shipment of wheat by rail avoids trans-shipment expenses at Buffalo, saves insurance cost which usually accompanies marine shipment, and insures speedy delivery, which means quicker marketing, quicker overturn of capital, and avoidance of the danger of heating the grain. Nevertheless, in spite of these advantages which the railroad enjoys, the lakes have maintained the lead since 1865 except for a few years at a time, and since the middle of the eighties uninterruptedly. This has been due largely to the northwestward movement of the surplus wheat area which is now directly west of Lake Superior, and with Duluth as near Buffalo as Chicago, it is natural that a great export business should be built up at the head of lake navigation, even though the Duluth rate is higher than the Chicago rate. In flour the lakes have not been so successful, because the element of time is more important than in grain, because flour cannot be trans-shipped with the same ease and the same immunity from damage, and because in consequence, marine insurance is much more heavy.

Competition in the carriage of corn has been more favorable to the railroads than in that of wheat, partly

*Extracts from an address before the St. Louis Railway Club.

†Professor of Economics, Dartmouth College.

because corn is more subject to damage by heating, but mainly because the shifting of the corn area has been westward along the parallels and not northward. The competition for this commodity, produced in the states of Illinois, Iowa, Missouri, Kansas and Nebraska, has not been between lake and rail carriers, but between the railroads serving Atlantic and Gulf ports.

In the coal traffic westward, the railroads do an enormous business. Of the eastern coal and coke received by Chicago in 1904, considerably less than half came by lake and this was exclusively anthracite. It does not seem reasonable to suppose that the lakes will ever preponderate in this traffic even with the inducement of extremely low rates, and the added advantage that many of the steamship lines are in active alliance with the coal carrying roads. The railroads have perfected the mechanical handling of coal while there seems to be difficulty in rehandling coal economically at the ports. For Chicago and vicinity, the lake route is very roundabout. Moreover, the shortness of the lake season leaves to the railroads provision for the heavy winter demand for this fuel.

It has come to be generally acknowledged that taking the two forms of transportation as they exist to-day, rail transportation cannot compete with that on the Great Lakes in the matter of cheapness. This may be illustrated by comparing lake rates with those of railroad systems serving in part the same territory. The revenue per ton-mile received by the Lake Shore road on 4,610,710,625 ton-miles of freight in 1903 was 5.21 mills; by the Nickel Plate on 1,309,956,766 ton-miles was 5.27 mills. In striking contrast with these receipts is the lake rate which on 28,974,660,408 ton-miles of freight passing through the "Soo" was .92 of one mill. It is evident that railroads must have offered other advantages which offset the low lake rate in order to hold their own as well as they have done. But several facts should be noticed in this connection. In the first place, lake traffic is preponderantly through traffic and the low rate quoted is a through rate. The rate per ton per mile given for the two railroads covers a large amount of local traffic in which cost must necessarily be higher. Again, the railroad figure is made up from the aggregate freight handled, which includes both high and low grade commodities. Lake traffic is almost entirely raw products, and the traffic is so regular and homogeneous that facilities peculiarly adapted to its manipulation can be employed to the best advantage. But of far greater importance is the fact commonly overlooked by those who compare these rival means of transportation, that the right of way is furnished to the lake vessel free of charge. This does not mean that it has cost nothing to build or that nothing has to be spent in maintenance. It does mean that the people have paid through taxation for a 20-ft. channel from Duluth to Buffalo, and for the construction of a canal at the "Soo," and it means that the people are spending every year large amounts of money for deepening and straightening the channel and for keeping it properly patrolled and inspected. The people have also constructed adequate harbor and dock facilities to expedite the loading and unloading of vessels. It is certainly a fair question whether the railroads could not have made a more remarkable record than they have done in the matter of rate reductions if the government had built their roadways, kept them in repair and provided them with their station and terminal facilities. But I shall refer to this point again in the discussion of canals.

RIVER TRANSPORTATION.

A discussion of river transportation in the United States compels us to confine ourselves almost exclusively to a sketch of its past or to prophecy as to its probable future, for it is a fact which appears astonishing in comparison with the attention given to this form of transportation in France or Germany, that our river highways are almost absolutely unused at the present time for the carriage of passengers and freight. A glance at the statistics published monthly by the Bureau of Statistics of the Department of Commerce and Labor reveals the fact that but few rivers have traffic enough to warrant their inclusion in the statistical tables. The mighty Hudson does not appear in the list. It forms a part of the water shipment for traffic on the Erie and Champlain Canals and has some passenger and package business between New York and Albany, but it has no effect whatever upon railroad rates. The Monongahela as far up as Fairmont, West Virginia, 126 miles, is used extensively for the transportation of coal to Pittsburg and to points on the Ohio River. During the month of August of this year, the last for which statistics are available, 780,000 tons of freight were handled down stream, of which nearly 94% was coal. The up stream freight was 132,575 tons, of which sand and gravel constituted 94%. Of the total vessels engaged, considerably over half were coal boats, barges and flats. The Great Kanawha River handled during 1904 1,150,000 tons of freight, of which 93% was coal. The rivers which extend inland in so many of the Southern states are of practically no effect in competition with the railroads. Water competition has been attempted at Nashville on the Cumberland and at Chattanooga on the Tennessee, yet competent witnesses declare that such competition does not exist.

But turning aside from these smaller rivers which are of negligible value in our transportation system, we direct our attention to the Mississippi and its tributaries which drains an area of 1,240,000 square miles, or nearly one-third of the territory of the United States, and inquire what is the economic importance of this great highway at the present time. The total number of vessel arrivals reported at Cairo for the year 1904 was 5,577, of which 1,811, or 32%, were steamers, the remainder being classed as boats or barges. These figures indicate a stationary if not a declining tonnage. The impression gathered from testimony of witnesses before the Industrial Commission is that no increase of any importance has taken place since 1890. This impression is confirmed by tonnage statistics presented in the report of the Commissioner of Navigation which shows that the tonnage of the entire Mississippi system was 298,892 tons in 1893, and 215,095 tons in 1903.

A few facts may make clear the present importance of the river as a transportation agency in comparison with the railroads. In the year 1904-05, New Orleans received 8% of its cotton by way of the Mississippi; Memphis received 12% by this highway and shipped practically none. Of the total freight receipts of St. Louis in 1904, 1.25% came by river, including the Upper and Lower Mississippi, Ohio, Illinois, Missouri, Cumberland and Tennessee. This small percentage was 45,000 tons less than in 1903, and 120,000 tons less than in 1902. Of the total traffic out of St. Louis, .06% went by river, and this was nearly 130,000 tons less than in 1903, and 140,000 tons less than in 1902. The insignificance of river traffic at St. Louis appears more striking when a few of the separate commodities commonly handled by Mississippi steamboats are considered. Of the total receipts of cotton at St. Louis in 1903-04, 0.2% came by river, and 0.04% were shipped in this way:

Flour,	receipts 0.6%;	shipments, 0.8 %
Wheat,	receipts 3.4%;	shipments, 0.02%
Corn,	receipts 0.2%;	shipments, 0.28%
Lumber and logs,	receipts 1.6%;	shipments, 0.16%

The report of the St. Louis Merchants Exchange for 1904 shows that no export grain was sent to New Orleans by river during the year, and that but five trips by steamboat were made to that port. It is evident, therefore, that the lower Mississippi can no longer be regarded as a serious factor in the transportation problem of the cities along its banks.

The great traffic of the Upper Mississippi in the past has been lumber and logs, but this is rapidly declining with the exhaustion of the forests along its upper courses. The mills which used to line the banks of the upper river in great numbers are closing down and plants are being constructed in the northern woods, whence the lumber is being shipped out by rail.

The traffic of the Missouri, never large, has been practically wiped out by railroad competition.

On the Ohio alone does there seem to have been any increase in traffic in recent years, and that is confined almost entirely to the one commodity, coal. The coal sent down the Ohio from Pennsylvania and West Virginia is mainly destined for Cincinnati and other Ohio river points, but a large amount traverses the entire 2,200 miles to New Orleans. Fleets of coal barges in tow carrying 10,000 to 15,000 tons are made up at Pittsburgh, and when the stage of water is favorable, are brought down to Louisville where they are made up into fleets of from 35,000 to 40,000 tons, destined for New Orleans. The barges are made of wood. The strongest of them, after discharging their cargo, are towed back to the mines for reloading, but 70% of them are constructed as cheaply as possible and are sold for rough lumber in or near New Orleans. This cheap method of transport makes possible a rate of $1 per ton for the distance of 2,200 miles, or less than half a mill per ton mile, a rate that is superior to railroad competition.

Undoubtedly the early and very rapid development of our railroad systems and the desire, more urgent in America than anywhere else, for speed in transportation, has had much to do with this neglect of our waterways, but this does not wholly explain the fact that our greatest river lies almost unused. Let us note briefly its traffic history. The steamboat was launched on the Ohio River at Pittsburgh in 1811, but at first could only proceed down stream, because with its imperfect construction it could not make headway against the rapid current of the Mississippi. It was the year 1817 before a steamer succeeded in overcoming this difficulty. The invasion of the southwest by the new transportation agency opened up the section to settlement, and led to a prompt utilization of the river for the transportation of cotton, and for the shipment of supplies into the south from the new sections of the west. Steamboats on western rivers increased in number from 20 in 1818 to 1,200 in 1848, and a similar development took place in flat boat tonnage. The effect of this was shown in the development of the cities and towns along the river banks. Louisville grew from 4,000 in 1820 to 43,000 in 1850, St. Louis 4,900 to 77,000.

With the building of the Erie Canal in 182[illegible] of the central west bordering on the lakes, fou[illegible] access to market, and middle western commodi[illegible] had moved in a southerly direction altogether [illegible] time, were in part diverted toward the east, b[illegible] the city of New York with its splendid harbor [illegible] couraging the establishment of ocean lines se[illegible] port. With the opening of the Welland Canal [illegible] another route was provided through Lake On[illegible] the St. Lawrence to Montreal and Quebec. The[illegible] to the Gulf ports and the decided inferiority of a[illegible] ern port to that of New York, worked in fav[illegible] eastward movement of trade.

However, the river continued to occupy an i[illegible] place until the railroad reached the middle we[illegible] fifties. From that time it was doomed, for the r[illegible] with their constant improvements in mechanism [illegible] administration, were able to offer steadily low[illegible] and to accentuate the movement which the lak[illegible] canal had begun. The ocean lines improved their [illegible] to keep pace with railroad development and m[illegible] monopoly of the Atlantic ports secure.

It is only within a decade that this monopoly h[illegible] seriously questioned, and this has been brought about, not by the development of river traffic, but by the growth and perfection of railroad systems leading to southern ports, and opening up the middle and southwest to the foreign market through Galveston, Port Arthur and New Orleans. These lines with their easy grades and freedom from snow and ice have been counted upon to cut heavily into the east and west lines, but their difficulty up to the present time has been due largely to lack of return freights, so that one way movement of commodities has had to cover the expense of returning the empty cars. The inadequacy of steamship facilities at the southern ports which has handicapped this section can be accounted for partly by lack of return freights or imports.

Although the trade movement of the United States had operated prejudicially to the river almost since the middle of the century, undoubtedly the recent sharp decline of traffic on the Mississippi has been due to the perfection of railroad systems which parallel it and which are enabled as a result of easy grades to haul enormous train loads at very low cost. The nature of the river and the many difficulties of navigation have aided the railroads to make their advantage secure. The Mississippi is one of the so-called alluvial rivers which has not sufficient current nor banks of the right material to permit it to bear along the sediment delivered to it from its swifter upper courses. Instead of deepening its channel, it fills it in.

A second difficulty springs from the rapid fluctuations in the stage of water in the river. The river is subject to sudden floods. The stage of water at Cairo for the year from July 1, 1904, to July 1, 1905, ranged from 3.12 ft. in Dec., 1904, to 38.5 ft. in May, 1905, and the variation in a single month is often as much as 10 ft. Navigation is accompanied by great risks and the insurance cost on boats and cargo acts as a serious handicap in competition with the railroads. Moreover, steamers are often compelled because of the stage of water to lie inactive for many months of the year, thus losing the interest on their investment. Finally the fact should be noted that river transportation over almost its entire extent is closed for a portion of the year on account of ice.

But aside from these natural difficulties river transportation is handicapped in many other ways. Although freight steamers can underbid the railroads on many kinds of freight destined for local points, yet the railroads are enabled through a manipulation of rates to charge very low rates to points reached by steamers, and recoup themselves by higher charges at non-competitive points. Such a policy is not open to the steamboats, for the river being free to all there is no point that is non-competitive. River rates have unquestionably had an influence in keeping rail rates down, that is, they have fixed the maximum beyond which they cannot rise, but the disadvantages of water transportation make it unnecessary for the railroads to bring their rates down to the level of the water rate.

Railroads are able to provide much more efficient terminal facilities. The flexibility of the mechanism makes it possible by means of switch tracks to deliver and receive goods direct to and from the warehouses, thus saving the time and expense necessarily incident to the hauling of goods from the steamer wharf. This is one of the principal reasons why the railroads have absorbed the bulk of the through business. They are developing the southern ports through the erection of large wharves and piers which make it possible to bring the railroad car alongside the steamer. No such system of transfer has yet been devised for the river steamboat. Although it may be due to a steady falling off in business and a consequent lack of incentive, it is cause for remark that modern facilities and up-to-date business methods have not been introduced into river steamboating. The construction of craft differs little if at all, from that of the boats found on the river in 1850, and loading and un-

loading is [illegible] exclusively performed by roustabout labor which has [illegible]ned during succeeding years only how to make its demands for higher wages effective.

What conclusion, then, is to be drawn from these facts? Are these conditions permanent? Can the river be restored to its former importance as a transportation agency? This question cannot be answered positively. Any statement made at this time can only be regarded as a personal opinion. My own opinion I offer only with the greatest reluctance, realizing that I am speaking to the citizens of the greatest of river cities, who are keenly interested in the development of river traffic. I am cognizant of the work of the Ohio River Improvement Association which has secured appropriations for a survey of the Ohio River to deepen the channel to 9 ft. from Pittsburgh to Cairo, of the Upper Mississippi River Improvement Association and of the River Improvement and Levee Convention, looking to the execution of the same work on the upper and lower Mississippi. I am aware that these conventions have declared that such work is of the utmost importance to the industrial development of the sections served, and will make the river a powerful regulator of railroad rates. But I must confess that I am not over-sanguine as to the results of the execution of such engineering projects.

It must be borne in mind that such improvements in the Mississippi and its tributaries will represent an enormous investment of capital, and although this work if done at all should be done by the General Government, and although the people of the country will contribute cheerfully to this great work through taxation if the desirability of it is demonstrated, nevertheless, such a burden should not be thoughtlessly imposed upon the American people, and the work should not be undertaken until its projectors, after a careful estimate of all the factors in the case, are convinced that the results will be worth the cost.

CANAL TRANSPORTATION.

In the discussion of this phase of water-carriage, we shall exclude from consideration such canals as that at St. Mary's Falls connecting Lakes Superior and Huron, and the Louisville and Portland Canal round the falls of the Ohio at Louisville. These are but devices for making lake and river transportation more effective, and are clearly justifiable economically if they are warranted by the commerce on the waterways which they are designed to improve. Canal building began on an extensive scale before the advent of railroads, but many of them probably would never have been built had railroads first appeared. The only canals in the United States whose business is sufficiently regular to warrant the inclusion of their traffic in the government's monthly reports are the Chesapeake & Delaware, connecting Chesapeake and Delaware Bays, with an annual traffic of about 700,000 tons, largely lumber; the Chesapeake & Ohio from Cumberland to Georgetown, owned by the State of Maryland, transporting coal almost exclusively, the amount depending upon the extent of the congestion of paralleling railroads; and the New York Canals. Of the latter, the only one of importance besides the Erie is the Champlain Canal connecting the southern waters of Lake Champlain with the Hudson. This canal handled in 1903 only about 800,000 tons of traffic.

In view of its position historically and of the movement now under way for its enlargement, the Erie Canal demands more detailed treatment. The opening of this canal in 1825, as already noted, created an east and west waterway of the first importance for the industrial interests of the time, and for the next 25 years was the main highway of traffic between the middle west and the Atlantic coast. Proving inadequate to the demands of traffic, it was enlarged in 1862, and deepened from 4 ft. to 7, where it has since in large part remained, accommodating vessels of 240 tons with a capacity of 8,000 bushels of wheat. All tolls were abolished in 1882, and the canal has since been maintained out of the treasury of the state. The New York constitution contains a clause forbidding the legislature to sell, lease, or otherwise dispose of the Erie, Oswego, Champlain and minor canals.

The Erie Canal has not kept pace with the demands of modern business. The rapid development in efficiency of the railroads of the state, which can carry a maximum of 90,000 bushels of grain in a single train load, and the enormous demands of commerce through the Buffalo gateway, have left the canal far in the rear. Its total tonnage has been gradually declining for many years. The greatest tonnage ever secured was in 1880 when 4,608,000 tons were handled. In 1903 the total was 2,414,000 tons, which was about the same amount as in the fifties before the canal was enlarged. Of the total tonnage of freight carried by railroads and canals in New York, the canal tonnage has fallen with almost unwavering regularity from 68.9% in 1859 to 5% in 1903. In 1898 the New York Central and Erie railroads carried 46,000,000 tons of freight as compared with 2,300,000 tons on the Erie Canal. The bulk of the traffic consists of lumber, ice, stone, lime and coal. Less than 10% in 1899 and less than 8% in 1900 of the flour and grain received at New York came by this route.

Agitation in New York for resuscitation of the Erie Canal has had its rise out of the conviction on the part of New York's commercial interests that the city is losing its commercial supremacy and that other ports of the United States are developing at its expense.

The construction of a ship canal was one of the projects suggested. This has been dismissed as impracticable, at least for the present, because of its enormous cost and doubtful expediency. The proposition to enlarge the canal to a depth of 21 ft. to accommodate lake vessels has been rejected first because of the loss in investment that would result from the fact that vessels built to run 15 or 20 miles an hour would be reduced to a speed of five miles an hour for a distance of nearly 400 miles through the canal; and second, because lake steamers could not run alongside ocean vessels as the canal barges can do, but would require lighters, thus greatly adding to the terminal expense. The people of New York State have therefore authorized the Legislature to expend $101,000,000 in an enlargement of the Erie and other canals to a depth of 12 ft., carrying boats of the cargo capacity of 1,000 tons or 33,000 bushels of wheat, four times the present size. It is expected that better methods of propulsion can be employed, either electricity or steam, and that a canal boat, with three convoys, can travel at an average of four miles per hour night and day, thus reducing the time between Buffalo and New York from 12 days to 5¼ days. The advantages expected from such enlargement are a development of local business by the establishment of industries along its banks, a growth of through business in grain and lumber, in iron and steel products eastward and in coal westward, and a regulation of rail rates through the potential capacities of the new waterway. The estimated capacity of the new canal is in excess of 20,000,000 tons per annum, or about 30% of the total present freight traffic of New York State.

I have entered in detail into the discussion of the Erie enlargement because this plan has aroused much greater interest than any other American project, and because it gives greater promise of success. But there are many other proposals for canals in different sections of the country, extending all the way from projects that have some economic justification to the crazy and impracticable schemes of visionaries. A plan which is being pushed with vigor and has the influential endorsement of Engineer L. E. Cooley, of Chicago, is one to connect Lake Erie and the Ohio River by a canal of sufficient size to accommodate lake steamers, thereby converting Pittsburgh into a lake port. Another which has its supporters is the deepening of the Mississippi and Illinois Rivers to a connection with the Chicago Drainage Canal, thus making the latter a part of a commercial highway between Lake Michigan and the Gulf.

Supporters of the canal building policy are accustomed to refer to the results attained in European countries, particularly in Germany and France. It is worth while to pause over this matter long enough to show that the experience of these countries has little in it that can be properly applied to American conditions. In the first place, the great increase in traffic on the waterways of Germany and France has not been on canals proper, but on the great natural waterways, the Elbe, Oder, Spree, Rhine, Main, Seine and Marne, and enormous amounts of money have been spent in improving these rivers so that the cities far up their courses might be converted practically into ocean ports. These rivers are so well situated, and are navigable for such long distances, and drain such immense areas of country, that they become commercially available for widely scattered industrial interests. Of the total of 8,737 miles of waterway available for traffic in Germany a few years ago, 5,776 miles were rivers, and 1,451 miles were canalized rivers, leaving 1,510 miles for canals proper.

In the next place, it is to be observed that in both France and Germany the traffic on the canals, with very few exceptions, pays no tolls. Canal charges cover nothing but the actual cost of carriage. The waterway is not only constructed and improved by the state, but the annual expenditures for dredging, lighting, superintendence, and the maintenance of inland harbors, is a charge upon the treasury. Again it is to be noticed that in Germany and France both rail and water transportation are under direct control of the state. In Germany the railroads are owned, in France their dividends are guaranteed by the government. In neither country are they permitted to put into force competitive tariffs. In Germany the waterways have not developed new traffic so much as they have absorbed traffic largely handled by railroads in other countries, and the railroads, instead of developing through traffic at competitive rates, are being reduced to their earlier position as mere feeders of water transport. An active water development policy accompanied by railroad restraints has suited the German Government, and has proved profitable to the treasury in bringing in an enormous net revenue from short-haul railroad business at high rates. These conditions are set forth by witnesses whose authority is unquestioned, such as Ulrich in Germany and Colson in France. We must certainly conclude that it would be absurd to infer from the situation in these two countries that canal carriage is necessarily cheaper than railroad carriage. In fact, Colson goes so far as to assert that in most cases in France the net cost of transport is appreciably higher by water than by rail.

Mr. W. M. Acworth, of England, than whom there is no keener or better informed critic of transportation conditions now writing in the English language, in a recent article on British Canals, asserts that the alleged economic superiority of canals does not in fact exist. Among the distinct disadvantages, says Mr. Acworth, under which canals suffer, are the following: If when constructed, volume overtakes capacity, the canal cannot be gradually improved so conveniently or so cheaply as the railroad; although cheaper to maintain, it is often out of use, through summer droughts, winter ice and repairs of locks and banks under water; railroads by charging high rates on high grade goods, are able to give a very low rate on low grade commodities, whereas in canal operation freight traffic must bear all the expense unaided by supplementary revenue from passengers, mail and parcel traffic which the railroads enjoy; slow merchandise for which canals are alone fitted is becoming of relatively less importance every year in the sum total of traffic handled; the railroads can go anywhere, can offer a rapid and certain service and can provide adequate switching and terminal facilities, whereas canals, always slow and uncertain, are distinctly limited in their provision of terminals, and are confined largely to level country by reason of the fact that canal efficiency rapidly decreases when frequent changes of level are necessary.

Mr. Carnegie, once an advocate of the proposed Pittsburgh-Lake Erie Canal, made the following statement before the Pittsburgh Chamber of Commerce in 1898:

> Such has been the progress of railway development that if we had a canal to-day from Lake Erie through the Ohio Valley to Beaver, free of toll, we could not afford to put boats on it. It is cheaper to-day to transfer the ore to 50-ton cars and bring it to our works at Pitsburgh over our railway than it would be to bring it by canal.

What, then, in view of all these facts, must be our conclusion as to the proper policy for the United States to pursue with reference to the improvement of its waterways? I would not have you infer from the facts presented that I occupy a position of determined hostility to the improvement of our rivers and to the construction and enlargement of our canals. My plea would not be for an abandonment of all forms of water transportation, but rather for a thorough and conscientious consideration of all possible factors in the case before an improvement is decided upon. Two considerations should above all others be kept in mind in determination of the feasibility of any project; first, the very positive limitations to the efficiency of rivers and canals as transportation agencies because of their lack of flexibility and the natural disabilities under which they suffer; and second, that water transportation is not necessarily cheap simply because the government constructs and maintains the channels. Nothing could be more delusive than the assertion so frequently made, which is found in the opening pages of the report of the New York Committee on Canals of 1899, that water transportation is inherently cheaper than rail transportation. Such an assertion is true only of ocean transportation, and possibly also of large bodies of water like the lakes, although this last is doubtful.

By all means let us have our waterways developed when such development is economically justifiable. What is justifiable must be a matter of judgment, and possibly to some extent of experimentation, but the burden of proof rests on its advocates. Such projects should be carried out by the localities interested and the burden should be borne by those who are to derive the benefit. Only in large undertakings of national concern should the General Government be called upon for aid.

But I protest most vigorously against the deluge of schemes poured in upon Congress at every session by reckless advocates who, disregarding altogether the cost of their crazy measures in the increased burden of general taxation, argue for the inherent cheapness of water transportation, and urge the construction at public expense of works whose traffic will never cover the cost of maintenance.

A WRECK OF THREE TRAINS occurred on the Baltimore & Ohio R. R. near Fostoria, O., on March 11. A freight train ran into another freight standing to take water; parts of the wreckage were thrown over upon the opposing track, and a few seconds later a fast passenger train ran into the debris, telescoping several of its cars. Two persons were killed and over a dozen were injured. The accident occurred in a heavy snowstorm.

A VERY LARGE TANGENTIAL WATER WHEEL unit is being built for the Colgate power house of the California Gas & Electric Corporation by the Abner-Doble Co., of San Francisco, Cal. The machine is a two-wheel, two-bearing water wheel, and will at first operate under a head of 660 ft., delivering 8500-HP. Later, it is planned, a new pipe line will be built, increasing the head on one of the wheels to 1,050 ft., and increasing the output of the unit to 13,000-HP. The speed of the machine is to be 300 r. p. m. It will drive a direct-connected alternator of 5,500-KW.

ASH HANDLING PLANTS AT RAILWAY ASH PITS.

Probably a large majority of the ash pits at railway yards where the ashpans and smokeboxes of locomotives are cleaned have a depressed track alongside the pit, and the ashes are shoveled by hand into cars standing on this track. There is, however, an increasing number of cases in which the ashes are handled mechanically and the depressed ash-car track is dispensed with, and two ash-handling plants of this kind are described below.

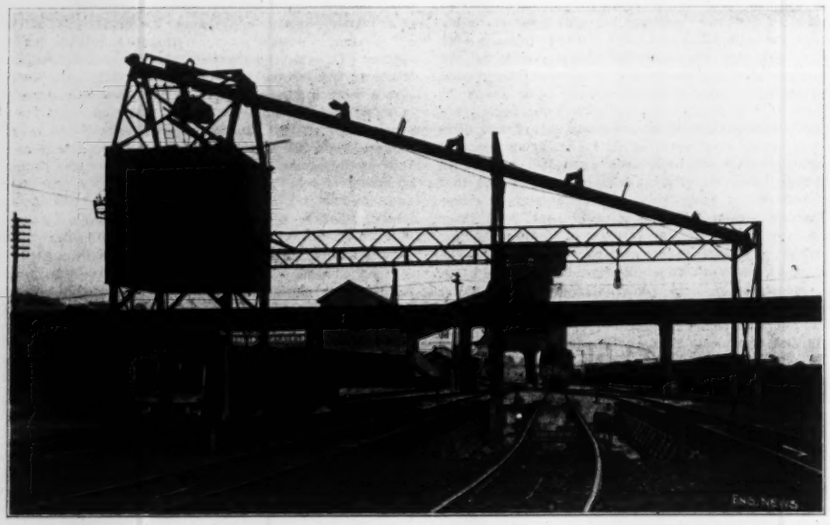


FIG. 1. FOUR-TRACK ASHPIT AND ASH-HANDLING PLANT, AT McKEES ROCKS, PA.; PITTSBURG & LAKE ERIE RY.

The locomotive terminal of the Pittsburg & Lake Erie Ry. at McKees Rocks, Pa. (near Pittsburg), is notable both for its mechanical ash-handling plant and for the exceptionally large ash-pit arrangement, which greatly facilitates the prompt handling of a large number of engines. In very many cases only a single-track ashpit is provided, which makes it difficult to get any one particular engine cleaned, and even a double-track pit is apt to cause serious detentions and a congestion of the entire facilities when a heavy run of freight traffic puts these facilities to the test. At the McKees Rocks yard, there are two coaling tracks opening into four ashpit tracks, which again converge to a track leading to the roundhouse or from which the engines can be switched to a running track in case they are to be sent out on the road immediately. The pit is 125 ft. long and 53 ft. 7 ins. wide, with concrete floors and walls. The floor is sloped from the middle and each end to two transverse drains leading to manholes on the drainage system of the yard, and upon the floor are pedestals of vitrified brick, 5 ft. c. to c., supporting lines of I-beams upon which the rails are laid.

Apart from the pit arrangement, the method of handling the ashes by mechanical means is of special interest. In each pit is a narrow gage track for steel cars or buckets mounted on small trucks, and the ashes from the engines fall directly into these cars. The buckets are 5 ft. long, and of 47 cu. ft. capacity. The loaded cars are run to the middle of the pit, which is spanned by a hoisting and conveying plant; the hoist picks up the bucket from off its truck, raises it, and carries it up an inclined runway to a point over the elevated ash bin, where the bucket is automatically dumped. The wire cable of the hoist is attached to a drum driven by an electric motor, the operations being regulated from two controller stands in the pit. The inclined runway has three adjustable stops over three of the tracks, and these can be raised to allow the trolley to pass or lowered to stop the trolley and cause it to lower the bucket at any desired pit track. A long operating rod parallel with the runway is connected to the stops, and has a rack gearing with a pinion which is driven by a bevel gear through a chain passing over a wheel on the middle column. The ash-bin is lined with concrete (reinforced with expanded metal) and has a capacity of 35 tons. It spans an extension of the coal supply track, and from a bottom chute the ashes can be delivered into the empty coal cars.

The coaling station serves two lines of engine tracks, and has storage capacity for 500 tons, while it can handle about 70 tons per hour. A train of several coal cars is set on a track of 0.75% grade, so that they can be fed by gravity to the coaling station as required, and after being dumped pass on to the ash-bin to receive a load of ashes.

The view in Fig. 1 gives an excellent idea of the whole plant; it shows the ash tracks and pit with ash cars in place, the controller stands for operating the hoist, and the hydrants for washing out the pit. Beyond the pit is the coaling station (spanning two tracks) and at the left is the ash-bin over the empty coal-car track. Fig. 2 is a sectional elevation showing the general construction and dimensions. For plans and other information we are indebted to Mr. J. A. Atwood, M. Am. Soc. C. E., Chief Engineer of the Pittsburg & Lake Erie Ry. The ash-handling plant is the only one of its kind that has yet been built, and was installed by Heyl & Patterson, of Pittsburg, Pa.

In the Robertson ash-handling system, Fig. 3, the ashes are discharged directly into steel cars in a pit that is just long enough for one engine. These cars stand on tracks which are at right angles to the engine track, and are carri[ed] on a steel framework at an angle of abo[ut] to a dumping position directly over a su[itable] track for ash cars. For small plants one [car] will suffice, but ordinarily each pit has [three] cars, two for the firebox and the other for [the] smokebox cinders. The cars are of about 2 [tons] capacity, and each car is attached to a [cable] operated by a vertical air hoist cylin[der] 10" × 84 ins., so that all operations are contro[lled] by the turn of a valve located at one end [of] the pit. Sheaves are used to give the necessar[y] travel to the car with the 7-ft cylinder, and th[e air] pressure is usually 60 to 80 lbs. Ordinar[ily] an air-pipe is run from the power house, but [for] small plants the brake hose on the tend[er] can be coupled to a pipe between the tracks and the machine then operated by air from the locomotive. In this system no storage of ashes is provided for, but the ashes are delivered direct to railway cars for removal. The construction is shown in Fig. 4. The method of dumping the ash-pit cars is one of the special features and is extremely simple, no latch or locking device being required. The entire bottom of the car is hung from hinges at the back end, and has beneath it a small wheel running on a rail between the car track rails, which thus holds it up against the body. At the upper end of the frame, however, this middle rail is bent to a horizontal position (Fig. 4), so that as the car ascends on the inclined rails the small wheel runs from under it, allowing the bottom to fall and discharge the contents.

There are 30 of these plants in use on some 14 railways, including about a dozen on the Grand Trunk Ry. The largest is at the West Milwaukee yards of the Chicago, Milwaukee & St. Paul Ry., and this is the plant shown in Fig. 3. This is a double plant with two ash-pits (on opposite sides of the ash-car tracks) and serves about 200 locomotives per day. An interesting application of this system has been installed by the Pennsylvania R. R. at Roadside, Pa., to handle the ashes from a power house to a track on the hillside at a considerable height above and horizontally distant from the power house. This system was invented and patented by Mr. William Robertson (formerly Master Mechanic on the Grand Trunk Ry.), and is handled by the Robertson Mfg. Co., 77 Jackson Boulevard, Chicago.

Another method of handling ashes directly by means of small cars in the ash-pits has been installed at the new East Altoona yards of the Pennsylvania R. R. There are four parallel pits, 240 ft. long, operated in two separate groups. Each pair of pits is served by a 5-ton electric overhead crane of 61 ft. 6 ins. span, traveling on runways supported by steel bents of triangular section. The rails of the runways are 22 ft. 6 ins. above the ground. The crane spans the two ash-pit tracks and two tracks for ash cars (one

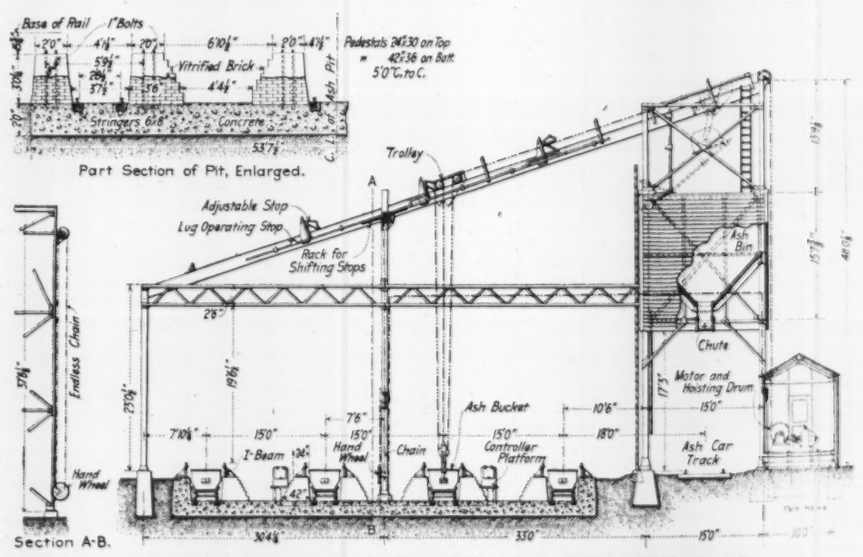


FIG. 2. CROSS SECTION OF ASHPIT AND ASH-HANDLING PLANT.

of which is between the ash-pits), all the tracks being 17 ft. 2 ins. c. to c. The pits are narrow, and each has a track of 2 ft. 4¾ ins. gage for iron trucks carrying drop bottom buckets which are handled by the cranes. The buckets are 6 ft. 5 ins. long and 3 ft. 8 ins. wide, made in two sections divided longitudinally and hinged together at the top; the sides are inclined inward

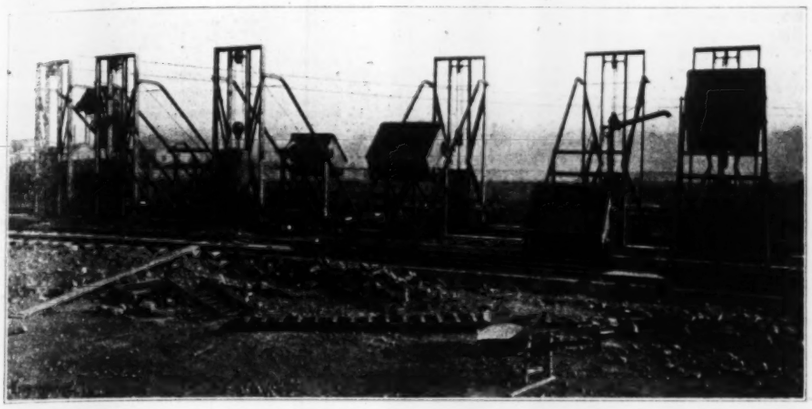


FIG. 3. ASH-HANDLING PLANT AT WEST MILWAUKEE, WIS.; CHICAGO, MILWAUKEE & ST. PAUL RY.

to form a V shaped hopper. The speeds of the crane are 400 ft. per minute for the travel along the runway, 150 ft. per minute for traversing the trolley, and 85 ft. per minute for the hoist.

COMPETITION BETWEEN RAILWAY AND RIVER TRANSPORTATION IN THE EARLY PART OF THE RAILWAY ERA: A LEAF FROM THE HISTORY OF THE HUDSON RIVER R. R.

One of the most famous names in the annals of early American railway engineering was that of John B. Jervis. There has recently been brought to our attention a notable paper, written by Mr. Jervis for "Hunt's Merchants' Magazine," in 1850, in which the history of the Hudson River R. R. was sketched, with especial reference to its influence on the railway movement. We have deemed a part of this paper worth reprinting at this time, not alone for its historical interest, but for its discussion of the question of rail vs. water transportation in passenger traffic, as it was viewed sixty years ago. That railways were supposed to be unable to compete with river steamers at that time for passenger traffic will be news, doubtless, to engineers of the present day.

It is also of great interest to note the evidence that at that time railways were chiefly considered valuable from the point of view of passenger carriers. Mr. Jervis, in computing the probable earnings of the Hudson River R. R., omits mention of freight receipts entirely except to remark in connection with the traffic returns of the railways entering Boston that "the passenger portion of receipts is conceded to be most productive of net income."

We are indebted to Mr. H. Lehn, of the maintenance of way department, N. Y. C. & H. R. R. R. for the copy of Mr. Jervis' paper, from which the following condensation has been made:

It has been justly said of the railway that it marked "an epoch in the affairs of mankind." Since the experiment of the Rocket on the Liverpool & Manchester Railway, a totally new impulse has been given to improvements in the means of intercommunication. Numerous localities were readily found, well adapted to this new method, and railroads multiplied rapidly. They have gradually improved in stability of structure, ease of line and grade, and in the machinery they bear, producing greater speed, safety and comfort to the traveler. But high as they were held, for routes usually adopted, the idea that they could successfully compete with the steamers on the Hudson was regarded in general as preposterous.

In this view, the history of the Hudson River Railroad affords an interesting instance of the working of the public mind, on a project whose origin was marked by almost universal incredulity. In addition to the formidable competition of the river steamers, it had a rugged, difficult and expensive line to execute; seen daily by thousands from the splendid steamers ploughing majestically the smooth, deep waters of the Hudson, they could only regard the herculean labor of constructing a railroad on its margin as a wild, visionary and unpromising enterprise.

In 1842, citizens of Poughkeepsie and other towns on the banks of the Hudson, employed Mr. R. P. Morgan, a civil engineer, to make surveys, with a view to ascertain the feasibility of the route along the Hudson River for a railroad from New York to Albany. Mr. Morgan started from the Harlem Railroad, where it crossed the Harlem River, and followed the north bank of the river to its junction with the Hudson, 13 miles north of the city of New York, and thence followed the eastern shore of the Hudson to Fishkill Landing, about 47 miles. From this point he diverged from the river, ascending to the general elevation of the table land, which he pursued to Kinderhook, and then descended to the river at Albany. He made a map and profile of the line, which he submitted, with a report and estimate of the cost of construction, all presenting a very favorable view of the project. With these, the friends of the measure went forward to procure from the legislature authority to construct the work. But the measure was regarded as chimerical, and an act of incorporation was refused.

At this time there was much anxiety for a railroad between New York and Albany, and many attempts were made to promote such a work; but it was generally supposed it must be made on an interior line, far removed from the river, that could support itself without reference to the river competition in the season of navigation; for it was believed by very few that the railroad could ever transport passengers in competition with the steamboats on the Hudson. It was therefore thought that to have the benefit of a railroad in the winter season it must be carried so far back in its main line from the river that it could do a summer business. In this view, a charter had been obtained about 1833, and a company organized to construct the railroad. This company did very little, and finally their rights were merged in the Harlem Railroad Co., or forfeited by neglect.

In the month of September, 1845, a convention assembled at Poughkeepsie to consider the project of a railroad between New York and Albany along and near the bank of the Hudson. They appeared to regard Mr. Morgan's line as the basis of their action, and appointed a committee to procure a more full survey of the route between New York and Fishkill Landing.

A short time after the meeting of this convention James Boorman, Esq., called on the writer, John B. Jervis, and requested him to make a survey, as above, and then to make a reconnaissance of Morgan's line from Fishkill Landing to Albany. Mr. Boorman stated that he was authorized to say that $1,500 would be raised to defray the expense. This sum of $1,500 was small to make a survey, maps, estimates and report, on such a line, 60 miles in extent; but, by allowing no compensation to the principal, except in the event of a successful organization of the company, and employing some portion of the assistant engineers, who would be willing to engage on the basis of future employment, if the project should succeed, a party was organized, and kept in the field near two months; and a portion to make maps and calculations some six weeks longer. The expense, including $142 for engraving and printing, was about $1,200, the remaining part of the $1,500 being appropriated to other objects in the prosecution of the project. The result of this survey, and a reconnaissance of the line of Mr. Morgan, from Fishkill Landing to near Albany, together with remarks on the importance, the feasibility and productiveness of the work when constructed, were presented in a report by the writer, and was read to a meeting assembled at the request of the committee in the University of New York, on the 23d day of January, 1846.

The meeting was highly respectable in point of numbers and character. The project was fairly laid before them, and all seemed anxious that the work should be done, and appeared to regard it as much wanted to promote the interests of the city. It was evident, however, that it lacked one element essential to such projects—that is, confidence in its ability to remunerate the out-

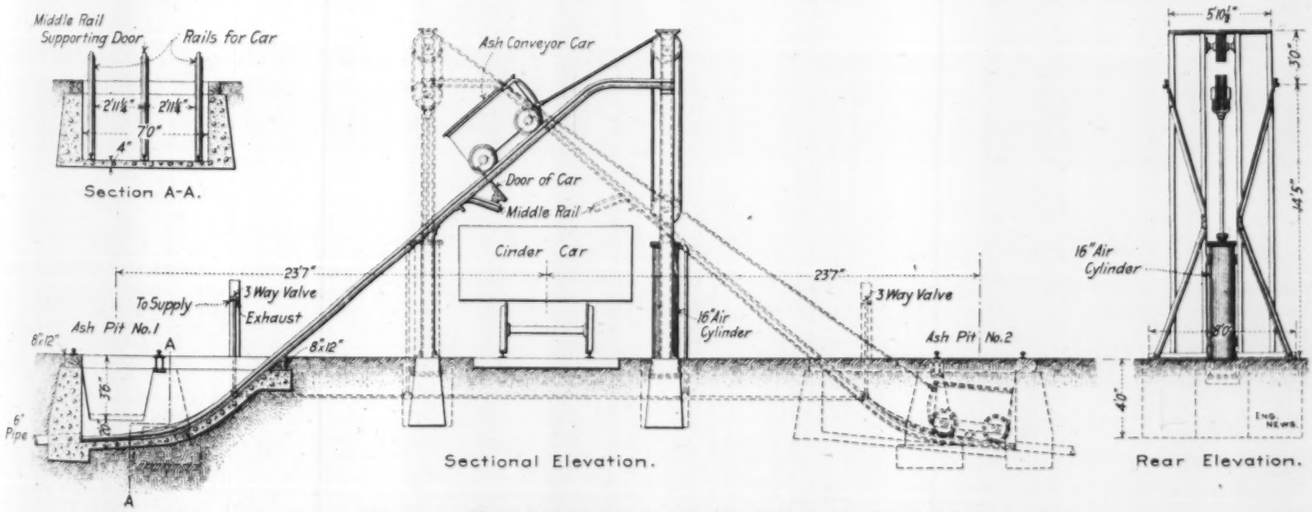


FIG. 4. CROSS-SECTION OF ROBERTSON ASH-HANDLING PLANT.

lay required. All were ready to speak favorably, but very few ready to take any pecuniary responsibility. In this state of the project application was made to the Legislature for an act of incorporation, and memorials were circulated for signature. Opposition to the measure soon manifested itself from various quarters, and little hope could be indulged of success without the personal attendance of some friend at the seat of government. On the 17th of February the small number of friends to the project, who were disposed to contribute their attention and give some direction to its interests, had a meeting for consultation. At this time they were composed of James Boorman, Stephen Allen, Saul Alley, Robert Kelly, James Hooker and the writer. The main question discussed was, who should proceed to Albany to prosecute the application for a charter. No one of the number was disposed to make this sacrifice; but finally the writer agreed to undertake the duty, and his associates agreed to pay $275 towards the necessary expenses. On the 20th a memorial, reasoning the case and urging the action of the Legislature, was signed by the above, and by James N. Wells and P. A. Cowdry.

The opposition to the act of incorporation was mainly concentrated in the Harlem Co. They regarded the Hudson River project as adverse to their interests, and they made all the opposition they could to its success. Many of the land owners on the banks of the river were violently hostile to the projected railway, and united their efforts to defeat it. Various reasons were urged; but the one that had the most influence was that the granting this charter would discourage capitalists from going forward with the Harlem Road, and that there was no reasonable probability the friends of the Hudson River line could obtain sufficient funds to construct it, even if they obtained an act of incorporation, and the granting them authority would only result in procrastinating the construction of a railroad on either route. Other parties were more or less active, as they regarded the project likely to interfere with their interests. After a struggle of nearly three months the act of incorporation was passed, whereupon the friends of the enterprise were duly organized for the business of obtaining the necessary funds.

The great question was to obtain a subscription of $3,000,000 to the capital stock. To obtain the funds necessary for so great a work, in the face of strong opposition from adverse interests, with the public mind deeply impressed with the magnitude and difficulty of the undertaking, and, moreover, with the idea that in the face of a competition with the most splendid steamers, on a navigation unsurpassed for their purpose, its traffic would not afford remuneration, was a task that few were willing to encounter. Competition with steamboat navigation was the peculiar feature in the traffic of the projected railroad; and this was an untried peculiarity. In the face of great discouragements, the Board of Commissioners had frequent meetings, and devoted much time in collecting information. On the 10th of June they published a prospectus, in which they set forth their views, and expressed the most entire confidence in the importance and productiveness of the proposed work. In September following subscription books were opened; few, however, were obtained, except those of the Commissioners themselves. They continued to exert their efforts in every way that promised success; by the publication of short articles in the newspapers and more systematic essays in pamphlets, taking subscriptions from individuals as they could be persuaded, and enlisting all to assist, that could be induced to aid, by their influence on others. The considerations of the importance of the project to the commercial and social interest of the city and State were enforced with unwearied perseverance, until the population of the city and the river towns were aroused to a state of excitement greatly in contrast with the feeling that existed in the early history of their effort. The result was the completion of a subscription of $3,000,000 to the capital stock of the company by the 1st of March, 1847, the day limited by the charter.

On the 4th of March, 1847, the company was organized by the following gentlemen, under the act of incorporation, as directors, namely: Stephen Allen, James Boorman, Saul Alley, William Chamberlain, Robert Kelly, Governeur Kemble, James N. Wells, Gardner G. Howland, James Hooker, Aaron Ward, Fortune C. White, Thomas Suffren and the writer. William Chamberlain was elected President, and the writer (John B. Jervis), Chief Engineer.

Immediate steps were taken to proceed with surveys, and in two weeks a party of engineers and their assistants were in the field, and a few days later two other parties were at work. The location of the line involved a large amount of labor. On one side lay the water and on the other the bold and rugged banks of the river. The zig-zag line of the river shore rendered it necessary to carry the railroad across the bays and through the projecting lands in order to obtain a suitable line for the work. To do this in such a manner as to secure a good line at the least expense involved extensive measurements and computations on very irregular ground, in order to determine what amount of cutting on the points would be sufficient to fill the bays between them. The difficulty of this duty was peculiar, from the uncertainty of the bottoms that required to be filled. These were sounded to ascertain the depth of soft mud; but as the mud varied considerably in consistence, the sinking that would take place, under the load that must be laid upon it, was necessarily more or less a matter of conjecture.

As soon as maps of location for the respective divisions could be prepared the directors proceeded to procure the right-of-way. The sums demanded for this were, for the most part, highly exorbitant. The amount paid may be considered, on the average, to be at least four times the real value of the land taken. It is believed very few, if any, of the owners would be willing to have the railroad removed, and their land restored to its original condition. Could more time have been taken this expense would no doubt have been much reduced; but the anxiety to proceed with the work overruled.

The line of work from 32d Street in New York to Breakneck Hill, a distance of 53 miles, divided into 39 sections, was offered for contract on the 20th July, 1847. A few days after proposals were accepted by the Board of Directors for the whole of the sections, and the contracts were executed for the greatest part in a short time after. Some of the persons whose proposals had been accepted delayed to execute their contracts and others never appeared. It was, however, mostly got under contract before the 1st of September.

The character of the work did not, in general, permit it to be commenced as promptly as could be done on inland roads. Embankments were to be carried across the river bays and along the margin of the river, where most of the filling was required; and it was necessary, in all earth work, to construct a river wall to protect the earth from being carried away by the surf from the river. This rendered it necessary to bring the stone for this purpose by boats, requiring an outfit not usually necessary, and the process was not familiar to many of the contractors, and hence arose indecision and delay. The greater part of this protection wall occurs where an artificial foundation is made by filling in a mass of loose stone, which is brought up to low water level and then levelled off and the wall commenced. The wall is about 7 ft. thick at the base and 3 ft. at the top. As soon as the foundation was prepared the work was commenced at low tide and prosecuted until the rise of the tide obstructed further work, and then left for the next tide. Until the wall was brought to high water level the work was very much embarrassed by the interruptions in waiting for the proper state of the tides. It might be supposed the river navigation would afford great facilities for bringing stone to the work, and this was no doubt useful, when they had to be obtained from a distance of several miles or from the opposite side of the river; but there was a serious drawback to this facility from the position and circumstances under which the vessels had to discharge. There could be no wharf, and the state of the wind and tide often prevented the vessels from coming to the spot or laying where they could unload—a circumstance materially embarrassing to the progress of the work.

The collection of materials, the erection of temporary buildings and providing tools and machinery occupied the attention of contractors so much that only a small amount of work was done during the fall of 1847. The total amount, up to the 1st of November, was $36,425, and to the 1st of December, $77,600.

In June, 1847, two parties were organized under the direction of John T. Clerk, Locating Engineer, to survey the line from Fishkill Landing to Albany, a distance of 83 miles. Two routes were surveyed; one inland, on a line run by Mr. Morgan, and the other on the margin of the river. The survey was made with great care, and the question submitted to the directors in a report made by the writer on the 12th of January, 1848. The report, after fully, and, as is believed, frankly discussing the two routes as to cost and capacity of business, recommended the river route as the best calculated to answer the great objects of the enterprise. Great local excitement was produced, and the report was attacked with much severity by those who entertained different views as to the policy recommended. After a delay of several weeks, for examination, the Board of Directors adopted the river route, as recommended by the report. At a future day it will be interesting to look over the discussions that arose on this question. To adopt the river route was claimed in the style somewhat of the Spanish Don to be a desecration of the river, marring its beauty and subverting the purpose of the Creator.

The rock cutting in the Highlands was particularly hard, more so than the writer has known elsewhere. A large portion of it was such that the amount of a man's labor at drilling would range from 1 to 2 ft. only.

Much embarrassment resulted to the progress from the sinking of the embankments and walls in the river bays. It often happened that after the wall and embankment had been brought to near the proper level the whole would go down, totally destroying the wall, except so far as it aided by its mass to form a foundation for the future structure. This operated greatly to discourage the contractors, and defeat the expectation of the engineer.

The following items will give an idea of the magnitude of the work:

Length of line—New York to Poughkeepsie ..... miles
" of line exposed to the action of the river ..... "
" river wall ..... "
" bridging ..... "
" tunnelling ..... feet
Excavation of earth ..... cub. yds.
" rock—open cutting ..... "
" " tunnel cutting ..... "
Loose stone in foundation of walls, &c. ..... "
River walls ..... "
Masonry, mostly hydraulic, about .... "
248 culverts, for water courses, mostly hydraulic masonry.
15 bridges of arched masonry, for roads over and under railroad.
25 bridges of masonry, with wooden superstructure, for roads over and under railroad.

The cuttings of both earth and rock were transported to form the long embankments across the bays, which greatly increased the labor of excavation. The cuttings, or excavatings, were nearly consumed to form the embankments, and very little spoil bank was made. In general, very little borrowing of material has been made, avoiding the necessity of mutilating the country for this purpose and the expense of double cutting.

The policy of as rapid a prosecution as warranted by a discreet regard to expenditure is fully approved. And regarding the physical obstacles this work had to encounter, the embarrassments in obtaining the right-of-way, the paralyzing effect of the cholera (which at times wholly suspended the work on heavy sections, and for weeks greatly prostrating all energy in its prosecution), and the unlimited experience for this peculiar work, it is fully believed, the accomplishment has been quite as rapid as was consistent with the interest of the stockholders.

The engineering duty, as has been observed, was peculiarly large, owing to the very rugged nature of the river shore and the difficulty of running and maintaining the line in the numerous bays. Notwithstanding the cost of this item, embracing the location of the line and the superintendence of the work to its completion, is only about half what it cost in England to make what is termed a parliamentary survey and location of line preparatory to obtaining an act of incorporation.

The work has had to contend with embarrassments common to great projects that are brought forward in advance of the public sentiment. Many honestly believed the effort would be a failure; and established interests liable to be injuriously affected by its success, were on the alert to keep up this impression; and, as a consequence, the progress of the work has been followed by unremitted predictions, that it could not be accomplished, or, if accomplished, it could never do a successful business in competition with steamers on the river. But its most important and difficult portion has been completed, and passenger trains of cars ran over 75 miles of the road within two years and ten months of the time when the subscription to the capital stock was closed, or an average time of about two years and two months after the general contracts were made for the respective sections.

CAPACITY OF THE RAILROAD FOR BUSINESS

As before observed, it was contended the road could never maintain the competition it must meet from steamboats. On this point subsequent experience on the New York and New Haven Railroad has done a good deal to enlighten the public mind in relation to railroads competing with steamers on the Sound. In this case so small a portion of travelers were taken by the boats that they were regarded as an unimportant competition. It was contended, however, that the navigation of the Sound was inferior to that of the Hudson River, and therefore this was not considered a sufficient test for the Hudson River Railroad. The very low rate of fare the road would be compelled to adopt to meet the competition of the boats, it was contended, would allow no profit to the railroad; and if it gained passengers by a high rate of speed, the number that could be carried would be too small to afford any profit to the company. It was well known that a locomotive could not carry the same load at a high that it could at a low speed. The friends of the road were therefore placed in a dilemma, either horn of which would be disastrous; for for if they run slow, so as to carry a large train, the boats would compel them to carry at so low a rate they could not pay, and if passengers were secured by a higher rate of speed, the expenses would be increased and the number of passengers be so reduced as to make it equally unprofitable. To carry passengers from New York to Albany in five hours, at a fare of one cent per mile, was pronounced by many persons, having experience in railroad matters, as totally ruinous, and this was regarded the highest rate of fare that could be commanded during the season of navigation. Notwithstanding all this alarming prediction, the writer was well satisfied the railroad would command a remunerating business.

It was important, under these circumstances, the road should be opened with engines of such workmanship and power that its friends would not be disappointed at the outset, and the writer bestowed much labor in ascertaining the form of boiler and furnace best adapted to generate steam, the essential of a locomotive. Some of the engines have been well built, and their performance has been highly satisfactory. Trains have been taken of nine passenger cars, containing about 500 passengers, with the necessary baggage, at a speed of 40 miles per hour, or making 40 miles in 1 hour and 23 minutes, including seven stops to discharge and receive passengers. Such trains have been frequently carried with one engine, the time varying from 1 hour and 23 minutes to 1 hour and 30 minutes. The time lost in stopping, including loss of way, rendered it necessary to maintain a speed of at least 40 miles per hour, when in full motion. This has been without any effort, and was the result of ordinary business. At one time ten cars were taken with near 600 passengers within the hour and 30 minutes. It is therefore settled by actual experience that the company have engines capable of carrying 500 passengers from the engine station in New York to Albany in four hours, a distance of 140 miles. For a new road, where the rail has not had time, by adjustment and use, to become solid and even, the speed and weight of train carried over this road is believed to be without a parallel. It is not supposed this would be the average number that would be carried in the ordinary operations of the business; nor that it will be the policy of the company to use so large engines (weighing 22 tons), but it fully establishes the capacity of an engine of 18 tons gross to carry 400 passengers as its greatest load, or an average of 200 passengers per train. At the estimated rate of a through passenger of $1.50, the receipts for the train would be $300. But there can now be no doubt that such a train, running through in 4½ hours, would command $2 fare, or $400 per train. The running expenses on this road should not exceed 80 cents per mile; say $120 for the trip, leaving net profit, applicable to interest, $280, or $1.95 per mile run.

The season at which the road was opened and the imperfect or partial manner it has been run (incident to the commencement of such an operation), has not fully established, as an experiment, its capacity to maintain a monopoly of the passenger traffic; but it has been sufficient to show its power of successful competition with steamers on the river. At a period about two months after the road was first opened, an account was kept of the number of passengers that left and arrived by steamers at Sing Sing, Dobb's Ferry and Yonkers, for six days in succession. It appeared by the account at Dobb's Ferry that the railroad took 83% of the whole number; the railroad fare 30 cents and the steamer 25 cents. At Sing Sing the railroad carried 85⅓%; railroad fare 45, steamer 25 cents. At Yonkers the railroad carried 85⅔% of the whole number; railroad fare 25 cents and steamer 12½ cents. At Peekskill the railroad fare was 55 cents, and the boats first charged 37½, and then fell to 25 cents; but the boats received so small a share that in a few weeks they drew off and left the whole business of this place to the railroad. With this experience there is no room to doubt that with a judicious management of four trains per day each way between New York and Peekskill, as special trains for this section of the road, there would not be business enough left for the boats to support them. Some of these trains should run from New York to Peekskill, others from New York to Sing Sing, and ultimately the business will require one to Dobb's Ferry. It is by frequent trains, running at a speed of 30 miles (running time) per hour, that will control and enlarge this traffic. To do this with profit to the road small engines of 12 to 14 net tons should be employed. They may be run at much less wear and tear of road and machinery. This arrangement of special trains to certain points will relieve the long trains from the necessity of stopping or being overloaded with short traffic. It is very material to the interests of this road that the closest attention should be given to its arrangements of running, so that, as far as practicable, its business may be done at a rate of 30 miles per hour, as higher speed will increase the expense.

No one will doubt the importance of carrying this railroad to Albany as speedily as is consistent with a due regard to economy, and the just interest of the stockholders. It is due to the latter, on whose funds the road has been so far made, that no measure should be adopted that does not consult their interests as a primary consideration. It is as much as can in justice be required of them, to go forward, if funds can be had, at a rate not less favorable than seven per cent. interest. If the funds cannot be had on these terms, to go on immediately, the company should confine themselves at present with putting the road now open, in the best condition to show its capacity during the next summer. The second track may be laid to Peekskill for about $350,000, and this will permit the road to be worked to good effect, such as will set the question of its capacity and productiveness at rest, and enable the company to command, on favorable terms, the funds to complete the line to Albany. In the judgment of the writer, the funds spent on a second track to Peekskill, will be of more value to the stockholders than a like amount on the line above Poughkeepsie. Nevertheless, if funds can be had on suitable terms, it is best to do both. The main difficulty of the enterprise has been surmounted, and, with prudent management, it may go through to Albany without material delay, or the necessity of impairing the value of the original stock.

In regard to rates of fare for passengers, it may be observed, this depends materially upon the number that may be carried per train. The average receipts for passengers on the seven railroads that enter in Boston was, for the year 1846, $1.37 per mile of train run, and for the year 1847, $1.34 per mile of train run. About 60% of their total receipts were for passengers. The last year (1847) they paid an average of 8.45% dividends, on roads costing an average of $52,000 per mile. The passenger portion of receipts is conceded to be most productive of net income. The receipts on the Hudson River Railroad for passengers, from the opening, Oct. 1, 1849, to Jan. 19, 1850, were $1.64 per mile of train run. The low fare on this road producing larger receipts than the high fare on the Boston roads, and this under imperfect arrangements, at an unfavorable season for traveling. The New Jersey Railroad, from Jersey City to Brunswick, has almost exclusively a passenger traffic, and with rates of fare averaging little over 1½ cts., summer and winter, pays 7% on a cost of near $60,000 per mile. The Hudson River Road can command 1½ cts. per mile in summer and 2 to 2½ cts. in winter, with an unparalleled amount of traffic. There will be very little difference in expense of running an average train of 100 or 150 passengers on this road, and enough has been done to show the business and capacity of the road to be greater than was originally promised.

THE INFLUENCE OF THIS RAILROAD.

It has settled the great question, that a well built railroad can successfully compete with steamers on the very superior navigation of the Hudson River, in the transportation of passengers; and consequently they will be required along all the great channels of steamboat navigation. We shall no longer look to the steamer, as heretofore, as the perfection of traveling, but shall cast about to ascertain what facilities are at command to obtain the superior conveyance. This question will be pressing, in proportion to the magnitude of the present and prospective traffic, on all steamboat routes, and we look to the southern shore of Lake Erie, as one of the first cases that must receive attention. Something is dong on this route; but it will not suffice until a first-class road is extended from Buffalo to the head of Lake Erie, and thence by the best and most direct route to Chicago, St. Louis and Galena. This will supercede the necessity of the boisterous and circuitous steamer navigation of the Lakes. The lake shore will doubtless furnish a grade essentially level and it is hardly possible to form an estimate of the magnitude of the traveling that will concentrate on this route, as soon as a suitable railroad is constructed on it. As steamboat competition can no longer be an impediment, it may be expected this most desirable route for a railroad will soon find the means for its construction, on a scale commensurate with the demands of the vast traffic that will flow to it. The dread of the steamboat on the Lakes being removed, the objects of business, information and amusement, will increase the social and commercial intercourse between the east and the west, beyond calculation. Galena and St. Louis, on the Mississippi, will be by this route within 1,150 miles of New York. From some suitable point on the great Lake shore route, one line will extend a little north of west to Galena, and another south of west to St. Louis. The distance from St. Louis to the city of New York will be about the same by railroad, that it is from New Orleans by the Mississippi steamers. Important roads are made, and in course of construction, through Ohio, from the river, reaching the Lake at Sandusky and at Cleveland, which will be great contributors to the shore road.

The construction of a great trunk railroad along the southern shore of Lake Erie, and extending in two main branches to St. Louis and Galena, with the numerous lateral roads that will intersect, some of which may be regarded as great lines, will produce vast results in diverting the trade that now seeks the seaboard through the navigation of the Mississippi. Nor is such a work to be regarded merely in relation to its commercial interests. Its influence on the social and political condition of the extensive and fertile district to be traversed, will be of incalculable advantage. The success of the Hudson River Road will hasten these great results. In view of the vast trade that will naturally flow from the extensive and fertile West to this city, for its Atlantic market, the importance of completing, on the most effective plan, all the great channels for the transit of persons and property that are now in operation or in progress through the State, from Lake Erie to the Hudson, must be obvious to the least reflection. The growth of the West, with commensurate improvements, will advance the interests of the city of New York in a proportionate degree, depending upon the perfection of those communications designed to accommodate the vast interests of trade and social intercourse that her natural advantages and position invites.

HOW TO SECURE A TECHNICAL POSITION.

By H. J. Hapgood.*

In this year of unprecedented prosperity, with the Panama Canal and other enormous enterprises literally crying for men, it is easy for a technical man of even mediocre ability to secure a position. The difficulty lies in finding the opportunity best suited to one's ability and the one which will not only pay the highest salary, but will offer the most favorable opportunities for permanency and advancement. The wise technical man will not lose his head simply because he has an unlimited number of positions within reach, but will look to the future and endeavor to connect himself with an enterprise where he can remain for many years, and even through a period of hard times.

The tendency to make frequent changes is the bane of many technical men. Not only does it detract seriously from their value to employers, but it injures the men themselves by scattering their energies without making them masters of any one thing. Of course, no technical man should hesitate to make a change if he finds himself in the wrong niche, but he should try to make as few changes as possible. The high-salaried specialist or technical executive reached his present place, not by continually changing, but by sticking to one line until he had mastered it and knew more about it than anyone else.

Having considered carefully the advisability of a change, every effort should be made to find a new position before resigning your present one. In the eyes of almost every employer the man at work has a value at least 25% higher than the one out of a job. To be able to say "I am now employed and am giving satisfaction," supplementing this with good reasons for desiring a change, has proved the open sesame to many a first-class opportunity.

The best method of finding the desired opportunity is by a personal canvass of employers. If you are a competent man and can submit blueprints or other samples of your work, together with one or two testimonials from former employers, you will have little difficulty in finding a place in these days, when companies are months behind with their orders through lack of draftsmen and engineers. In fact, in Pittsburg and one or two other cities the demand is so great that a man of the right experience can secure a place on trial with many firms on the strength of his own statements alone.

Another good method of marketing your ability is through one of the high-grade agencies, of which there are several, making a specialty of the needs of technical men. These are especially helpful if you are employed, because they act confidentially and there is no danger to your present connections until they have a satisfactory opening ready for you.

As a general thing, the want columns of the daily newspapers are of little use. Employers seldom use them for obtaining technical men, and very few positions of the better sort appear in them. You should watch carefully the leading trade papers, which frequently contain calls for specialists, and in which, at a small expenditure, you may place your qualifications before thousands of employers. Their news columns will also often furnish a clue to firms that will need men in the near future to help take care of increasing business.

A written application is one of the first steps on the road to a good position, and many technical men make it difficult through their inability to put their record clearly and forcibly on paper. A Pittsburg employer says that not one technical man in a hundred knows how to write a proper letter. "If they could state their experience and ability clearly on paper," he says, "it would insure them prompter consideration and often save them the expense of a personal interview before being engaged."

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Whether you use the machine yourself or not, your application should always be typewritten, with perhaps a postscript added in pen and ink to show what your lettering is like, provided this is a necessary qualification.

To put your case clearly and concisely is not the easiest thing in the world, and you may have to rewrite your application several times before it is in the best possible form. It should be in the form of an abstract of your qualifications and should, above all things, be brief. It should state your age, nationality, education, whether married or single, together with a concise record of your life and business experience up to date.

This last is, of course, most important, and should include definite description of all the positions you have ever held, with the names of firms, dates, duties performed, salaries received and reasons for each change. Any gaps in the record are sure to be disastrous. If you do not say what you were doing from June, 1900, to December, 1901, it may be thought that you were out of a job or in jail during that period.

The amount of emphasis to lay on your education depends entirely upon the character of the firm. In any case, it will do no harm to state the institutions you have attended, degrees received and subjects in which you have specialized; but when addressing a firm that will consider only technical graduates you can profitably say more about your education. Too many men are apt to overestimate the value of a technical school course. The completion of such a course only shows that they have gained a knowledge of fundamental principles, but does not prove that they have the common sense and native ability necessary to apply this knowledge and adapt it to special conditions.

Testimonials and references are valuable only to back up your personality and statements. They should be typewritten, but not printed, as when printed they indicate that you are perpetually in the market for a position. The originals, of course, are too valuable to allow out of your possession.

Too many testimonials are often ruinous. I know a man who was being favorably considered for a position as chief engineer and was on the point of being engaged. The negotiations were promptly called off when he produced 23 letters, of which 15 were from men for whom he had worked in the past three years. It is often better only to mention the names of firms from which you have letters and of other responsible persons to whom you can refer if desired.

Letters of recommendation should be brief and definite, one positive statement of what you have done being worth a dozen glittering generalities. One of the best testimonials I ever saw read like this:

> Mr. —— has been in our employ for five years. He is leaving because we cannot afford to pay him more than $1,800 and he is easily worth a higher salary. We are sorry to see him go as he is a competent civil engineer, and we shall have difficulty in filling his place.

Former employers are the strongest references you can give; teachers are the next best; friends, relatives and acquaintances carry the least weight.

Once inside the employer's office, you face the most difficult part of your task, and the part on which it is hardest to give advice. To win out, you will have to keep cool, think quickly and bring your best judgment into action. Above all, talk on the subject; don't talk too much and don't introduce unnecessary personalities. The employer is considering you, and he will not care to hear your wife's opinions or any other foreign matters. What you are expected to give is a frank, concise conservative statement of your experience, education and ability.

You increase your chances of success by preparing carefully for the interview. The advertising manager of one of the largest mercantile concerns in the East owes his position to thus priming himself in advance. One Monday morning he answered a want "ad." calling for a competent advertising writer, and an interview was appointed with the head of the firm at 9 o'clock the following day. The next 24 hours were strenuous ones for this young man. The afternoon he spent in looking up the firm's advertising matters; in the evening, in talking with friends about the firm's methods; the wee small hours, in thinking out ideas and catch phrases. He did not sleep at all, but when he went to his interview he had a good general knowledge of the firm's business, and as a result he landed the position.

Last, but not least, attend carefuly to your personal appearance. A smoothly-shaven face, clean nails, neat neckwear, fresh linen, well-polished shoes—these are essential and are better than expensive clothing, lacking them. If you cannot go to an employer without the fumes of tobacco or liquor on your breath, you had better not go at all, for ninety-nine times out of a hundred they will prove fatal to your chances. With neatness in your dress, a cheerful face, and nothing about you to suggest the down-and-out man, you have the way well paved for a fair consideration of your merits.

The expenditure of 50 cts. in a barber shop was once the means of securing a $3,000 position. The applicant was a mechanical engineer, long on ability, but mighty short on personal appearance. His case had been under consideration several weeks, and a definite answer was to be given the following day. The applicant, being not at all sanguine of success, went to a friend for advice as to how he could land the job, which was in every way just what he wanted. The friend said: "Go to a barber shop. Get a hair-cut and either have that scraggly beard of yours shaved off entirely or trimmed into some sort of civilized shape!" The engineer did this, and when he went for the final interview his personal appearance was about one hundred per cent. better. The employer engaged him without a moment's hesitation, and later confessed that the man's appearance had been the chief cause of the indecision.

When you enter the employer's office let it be with a clear idea as to the price you are going to put on yourself and stick to that figure. Do not, however, be afraid to lower your figure slightly at the start, provided you think the opportunities for advancement good. It invariably creates a good impression for a man to say, "Mr. Employer, I am worth more than you want to pay. However, I am willing to start at $900 to show you what I can do, with the understanding that if I make good you will advance me to $1,200 at the end of the month."

Both lack of confidence and overconfidence are to be avoided. A few months ago a well-known building firm was in great need of architectural draftsmen, and was considering a young man who had only limited experience, but demanded the highest price they were willing to pay. The chief draftsman was rather doubtful, but, in his anxiety to obtain a man, he agreed to take him on two weeks' trial. Before time to report for work the young man telegraphed that he was sick and could not take the position. The truth was that he realized that he was not worth the large salary he was asking and would not last longer than the probation period. Thus his overconfidence lost him a valuable permanent connection which might have been his by accepting a slightly lower salary at the start.

Overconfidence often leads a man to say that he can fill a position before he knows what it really is. In fact, this is a trap frequently set by employers to catch the unwary applicant. The kind of man they want is one who says, "From what I know of the proposition, I believe I can handle it, but I would not like to say so definitely until I know more about the work." Intelligent inquiries about the duties of a position are always more effective than empty boasts.

RESOLUTIONS OF THE PHILADELPHIA CITY COUNCILS AGAINST WATER METERS.

The outgoing (March 31) city councils of Philadelphia have hastened to record their unqualified disapproval of any and all efforts to install water meters in that city. Resolutions to that effect were passed by the common council on March 15, by a vote of 69 to 9, and by the select council, 33 to 0. The resolutions afford so striking an example of popular prejudice and ignorance regarding the object and effe[ct] meters that they are well worth putti[ng] for the benefit of engineers and city o[f]ficials where who are engaged in campaigns [a]gainst water waste and unjust methods of c[harging] water:

Whereas, in and by the reports to these Co[uncils] experts upon the filtration system of the city [of Philadelphia] ly recommended that water meters be inst[alled] city of Philadelphia in the homes of all the p[rivate] business houses and the manufacturing pla[nts] and,

Whereas, at most, the question of the utili[ty of] meters is no more than experimental, having t[he only] result, namely, a direct tax upon all who are [compelled] to use the same; and,

Whereas, experience has shown that whil[e meters] curtails the amount of water used, it also [materially] reduces the revenue of the city; and,

Whereas, these Councils are in favor of com[pleting] the filtration system of the city, and are willing [to provide] all the just and fixed charges and costs in connection therewith, they recognize also the fact that the sentiment of the community to-day is almost absolutely against the use and installation of water meters in any form and at any price, because it means the fostering of a gigantic trust, whose methods must bring a direct and onerous tax upon the tenants of every house in the city, and against which they can have little redress, because the free use of water is a pure and absolute necessity. It means, based upon the returns of 1905, that 311,547 meters must be installed, regardless of the fact that many of the houses of the city contain more than one tenant, and that the apartment houses are filled with thousands of different tenants so that every tenancy should have a separate meter, in all probability that upwards of 400,000 separate meters must be purchased by the city and installed at the ultimate expense of the tenant—a condition which must be deprecated at this time.

And Whereas, these Councils having received official information by submission to it of the report of Major Cassius M. Gillette, Chief of the Filtration Bureau, and John D. Maclennan, the filtration expert, that these water meters are strongly recommended for installation in the houses and property of the citizens of this city, which by acquiescence in accepting said report and taking no action thereon, may be construed to mean that these Councils indorse said recommendation.

Therefore, be it Resolved by the Select and Common Councils of the city of Philadelphia:

(1) That we unqualifiedly enter our protest against the use or installation of water meters in connection with the water supply of this city.

(2) That we believe at the present time that water meters, while they may be the means of saving the volume of water used, are not satisfactory, and may be the means of bringing injurious results to the health and prosperity of our citizens.

(3) That we stand ready and willing to vote all the funds necessary for the perfection of our water supply and the completion of the entire system of filtration, but not for one dollar toward the purchase or installation of water meters in connection with that system.

(4) That we believe the installation of such meters would mean, taking the interview of ex-Chief Hand as the authority, a reduction of about one-third of the revenue of the Bureau of Water, or a falling off of about $1,240,218, which with the proposed decrease in the revenues of the Bureau of Gas of about $668,000, must tend strongly toward the early increase of the tax rate; a condition which we deplore, and against which we protest.

(5) That upon the basis of 400,000 water meters, at an average cost of $16, as specified by the Chief of the Filtration Bureau, it would mean an expenditure of $6,400,000, all of which must ultimately be collected from the taxpayer or tenant of a property, without taking at all into consideration the necessary employment of hundreds of inspectors and the incidental expenses in connection therewith.

(6) That while we believe one department of the city government should not transgress upon the duties and rights of any other department, we desire to express our sentiment, as the legislative branch thereof, that those in authority will not lend their indorsement or power toward forcing upon the people who must use water any such system as will require its measurement by the meter, and we hereby urge those in control of our municipal government against the installation of water meters in connection with the water supply of the city of Philadelphia.

An abstract of the report by Major Cassius E. Gillette (now Chief of the Philadelphia Bureau of Filtration) and Mr. John Maclennan, M. Am. Soc. C. E., in recommending meters for every water consumer and city department appeared in our issue of March 8, and editorial comment on water waste prevention at Philadelphia and New York was published in our issue of March 15. Comment on the resolutions printed above may be found elsewhere in this issue.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
SAN FRANCISCO: Rialto Building
BOSTON: 170 Summer Street
ATLANTA: Austell Building
RUDOLF MOSSE, BERLIN AND HAMBURG, GERMANY

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Foreign Countries, Regular (Thick Paper) Edition, One Year, $8.00 (£1 6s. 8d.).
Foreign Countries, Thin Paper Edition (Construction News Supplement Omitted), $5.00. 21 Shillings, 25 Francs or 21 Marks.
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Entered at the New York Post-Office as Second-Class Matter.

The resolutions against water meters at Philadelphia, printed elsewhere in this issue, deserve the attention of all who are called upon to conduct a campaign of education against water waste. The resolutions contain such allegatons as that the use of meters is experimental; that meters reduce water revenues; that their introduction would mean "the fostering of a gigantic trust;" that "the *free* [italics ours] use of water is a pure and absolute necessity;" that meters would injuriously affect "the health and prosperity" of the citizens; and that they would "tend strongly toward the early increase of the tax rate." The readers of this journal are well aware that the only excuses for such fallacious statements are ignorance of the object and effect of meters and over-zealousness for the supposed interests of the public. Perhaps the most inexcusable of this series of fallacious claims is that the use of meters fosters a gigantic trust. Only last week we pointed out, in effect, that thus far Philadelphia has chosen to spend many millions for pumps, filters, reservoirs and pipes to each million that would have been required for waste prevention. In the resolutions already mentioned the Philadelphia councils declare that they

> stand ready and willing to vote all the funds necessary for the perfection of our water supply and the completion of the entire system of filtration, but not for one dollar toward the purchase or installation of water meters in connection with that system.

This declaration is in complete accord with the traditions and actions of the city councils and of most of the executive officers of Philadelphia for years past. The willingness to spend money for filters, up to the real needs of the city, is in every way commendable, but the continued rejection of every proposal to curtail waste is the reverse. Instead of declaring that meters will endanger the health and prosperity of the people of Philadelphia it is high time that councils see their errors, and that they confess them by declaring that the immense size and cost of unnecessarily large filtration, pumping and pipe systems, combined with the iniquities of huge non-competitive contracts, have delayed the completion of filtration works and already cost Philadelphia hundreds of lives, thousands of cases of sickness and millions of dollars in doctors', nurses', druggists', and undertakers' bills. Nor is the end yet: for capital charges, maintenance and operating expenses must be paid year after year on these vast needless expenditures. We can touch, at this time, upon only one other fallacy, implied by the resolutions in question, and often definitely asserted by other opponents to meters: it is that meters should not be used because water is a gift of nature, and should be free to all.

As a matter of fact, water, by the time it has been filtered, pumped, stored, piped and finally delivered under pressure, often costs the domestic consumer more, bulk for bulk, than does illuminating gas. Gas is universally sold by meter measurement and "dollar gas" is not only common now but is beginning to be considered a high charge in our larger cities. In many communities where gas sells for $1 per 1,000 cu. ft. the charge for water, to domestic consumers, ranges from $2.25 to $1.50 per 1,000 cu. ft. (or 30 to 20 cts. per 1,000 gals.). These rates for water are sometimes, depending on local conditions, unduly high, owing to the fact that the metered water consumers are wrongly called upon to pay for the water wasted by unmetered consumers. But the relative figures serve to show that water is not and cannot be free. It costs heavily at best, and it costs most where wasted most. The water meter reduces the waste, or if persisted in, makes him who wastes pay for it, and it distributes the cost of the water-works service among those benefited in direct proportion to what they use and waste. Without meters, as has so often been stated, the careful consumer is forced to pay for what is wasted and used by the careless one.

A very valuable paper on the relative economy of rail and water transportation is printed elsewhere in this issue, and is worth the careful study of every engineer interested in the larger problems of his profession. The author, who is Professor of Economics in Dartmouth College, shows the fallacy in the frequently reiterated claims made for the cheapness of water transportation as compared with railway transportation. The cost of rail transport always includes the cost of making and maintaining the roadway, and in comparing the cost of water transport with rail transport the cost of the waterway itself is almost invariably omitted. The reason this is done, of course, is that the cost of making and maintaining harbors and canals and of dredging and otherwise improving natural lake and river channels is borne by the taxpayers and is not paid as a part of that freight charge like the railway rate.

It is unfortunately the case that erroneous notions on this subject are widespread, and projects are constantly brought forward for waterways and improvements of waterways which are wholly unjustifiable and whose materialization would mean the misuse of enormous amounts of the taxpayers' money. Engineers, who can study this question from an expert standpoint, should lose no opportunity to assist in correcting such economic fallacies.

In the state of Ohio, by a law just enacted, a uniform rate of railway fare of 2 cts. per mile has now gone into effect. In New England the New York, New Haven & Hartford R. R., is of its own motion shortly to establish a uniform two-cent a mile rate over the whole of its system. There is reason to believe that this change is the beginning of a general establishment of the two-cent a mile rate throughout the whole territory east of the Missouri and north of the Ohio rivers including the Middle States and New England, with the exception of local lines, operated independently. While this change may mean some small reduction in passenger earnings for a year or two, its ultimate result is likely to be beneficial rather than otherwise. To a very considerable extent, existing variations in the railway passenger tariff have outlived their reason for being. They were originally designed to make the man who is compelled to travel and who will therefore travel whether the fare be low or high, pay more than the man who is only induced to travel by a concession in the fares. As actually applied, these variations now operate to discourage travel and reduce passenger earnings. An excellent illustration is the mileage ticket, which was originally confined solely to its purchaser or members of his family or firm. The difficulty of identification has caused many railways to entirely abolish these restrictions and make mileage tickets good to the bearer. While this results in a general use of mileage tickets instead of local fares, it has also created a swarm of local ticket brokers, who rent mileage tickets for a commission about as large often as the railway's net profit on its passenger business. Under such conditions it is evident that a flat reduction to 2 cts. per mile will benefit the railway. It will receive as high a fare as at present and its patrons will have practically lower fares.

In this connection it is of interest to note in the very interesting historical paper by the late J. B. Jervis, published elsewhere in this issue, that the Hudson River R. R., when opened for traffic, carried passengers from New York City to Peekskill, 40 miles, for 55 cts., and Mr. Jervis expected that a fare of only $1.50 would be charged for the whole distance from New York to Albany, or practically 1 ct. per mile. At that time (1846) Mr. Jervis stated that the New Jersey railroad, from Jersey City to Brunswick, "carrying almost exclusively a passenger traffic," and with rates of fare averaging little over 1½ cts. per mile, pays 7% on a cost of $60,000 per mile." Apparently, from other figures given by Mr. Jervis, rates of fare no higher than this were charged by the railways in the vicinity of Boston.

It is certainly a remarkable fact that while rates for freight traffic by rail have been reduced to a small fraction of those charged when railways were in their infancy, the rates for passenger travel are actually higher than those which were then in force.

In our correspondence column this week Mr. Clemens Herschel propounds and vigorously defends the proposition that if a sea-level canal were to be built at Panama no tidal lock would be necessary at its Pacific terminal, as has been generally assumed.

The majority of the Board of Consulting Engineers conceded in its report the possibility that Mr. Herschel is right; but to be on the safe side they planned for a tidal lock at the Pacific end of their sea-level canal. They believe, however, that the lock need not be used at all at neap tides, the tidal currents being then permitted to flow freely in and out of the canal. During the part of the month that spring tides occur, vessels would be locked in and out of the canal at low tide and at flood tide; but at mean tide:

> all the gates of the tidal lock could be open, leaving an unobstructed passage for vessels until the approach of the flood tide rendered it necessary for the gates to be closed until slack water would again be reached.

As Mr. Herschel points out, this should not be interpreted to mean that the lock gates could actually be left open for any considerable period of time at spring tides. A pair of canal lock gate—particularly of the size of those proposed at Panama—could not be safely closed with a current flowing through the lock chamber, even of very moderate velocity. Each of the gates for the Panama tidal locks would be a steel structure, some 60 ft. wide and 50 ft. high and heavy enough to dam back the wall of water behind it. Of course these gates could be opened at mean tide, but it would be necessary to close them in a few minutes, before the tidal current began to flow, for once a current started through the lock chamber they could only be closed with risk of injury.

In considering also the Board's statement that the lock gates could be open all the time at neap tides, it is necessary to remember that the section of the channel at the lock, as Mr. Herschel points out, is much smaller than the normal section of the canal. Reference to the sea-level sections on p. 204 of our issue of Feb. 22 will show that the canal from the tidal lock to Culebra has approximately twice the cross-section of the lock itself. Hence the current through the lock at neap tide would be twice as rapid as the current in the canal. While this current would be no obstacle to vessels going

with it through the lock, vessels attempting to pass through the lock against it might find some difficulty.

Turning now to the main question as to whether the currents set up in a sea-level canal at Panama without a tidal lock would be objectionable, we have to confess ourselves unconvinced by Mr. Herschel's arguments. He compares the 15 miles stretch in the Suez Canal between the Red Sea and the Bitter Lakes with the 45 mile length of the Panama Canal, and refers to the slope of water surface as if it were a uniform plane, with a maximum fall of 2¼ ins. per mile at Suez and 3 ins. per mile at Panama.

But as we view the problem, the water slope due to a tidal variation is not a plane surface but a curve. If the Pacific were constantly 10 ft. higher than the Atlantic, then there would be a uniform current and uniform slope all through the 45 miles from Panama to Colon. With the tidal change of level only lasting a few hours, however, the full velocity due to the change of level at Panama will not be propagated all the way to Colon. In other words the velocity of the tidal current will be greater, probably much greater, at the Pacific end than at the Atlantic end, 45 miles away. We cannot therefore safely compute probable tidal currents at Panama by simply dividing the total rise or fall of the tide by the total length of the channel. That this is true may be seen by assuming extremes, say a canal 500 or 1,000 miles in length, which, if the above method of computation were correct, would make the velocity of tidal currents at the Pacific end practically nil.

We are inclined to the opinion, therefore, that the Consulting Board's estimate of 5 miles per hour as the maximum velocity for the tidal currents is probably nearer correct than Mr. Herschel's estimate of about 3 miles per hour.

Finally, since Mr. Herschel admits that the precise limit of speed at which currents become of material hindrance to navigation is a debatable question, we would venture the opinion that while a canal *can* be navigated, doubtless, against currents of even five or six miles per hour, the more rapid the current in it or in any narrow channel, the more frequently will ships run aground. Ships do run aground in the Suez Canal, and not infrequently. They run aground in the channels at the entrance of harbors, all over the world, and probably the most common contributing cause to these groundings is the tidal current. The narrower the channel, the greater the liability that a vessel stemming the current will swerve from her course and strike the banks on either side. It may be said that in a canal, with vessels moving at slow speed, such grounding does not commonly injure the vessel. This is true; but even with the width proposed for the sea-level canal at Panama a vessel running aground will be very apt to block the canal. If the absence of tidal currents would reduce the liability to grounding, therefore, it appears to us that the lock could not safely be omitted.

New York City is humbly appealing to the authorities of New Jersey to permit Staten Island to obtain its water supply in New Jersey territory, on the ground that it is practically impossible for it to obtain a proper supply anywhere else. At the same time New York is objecting to the proposed discharge of the sewage of its New Jersey suburbs into New York Bay.

The proposal for a joint investigation, by New York and New Jersey, of the whole question of sewage disposal in the Metropolitan District of the two States, outlined on page 278 of our issue of March 8, seems to be meeting with general approval. While, as we stated at some length in our issue of May 4, 1905, we believe the Metropolitan District has far more pressing sanitary needs than relief from present and prospective pollution of New York Bay, yet we do believe, as we then stated, that the subject deserves careful investigation, to be followed by the formulation of a plan for future action, satisfactory and just to both States. Interstate cooperation, as we said a year ago, is far preferable to interstate litigation.

Another and still more forcible illustration of the effect of State boundary lines on great public utilities is the future water supply of Greater New York. That city is starting in on the development of a great new water supply from the Catskills which is estimated to cost $161,000,000. But if it were not for the State boundary of Connecticut, New York might draw from the Housatonic River a supply much larger than that from the Catskills at half the cost.

Ought there not to be, somewhere in our American scheme of government, some provision created for overcoming all these interstate difficulties? Until a better plan can be provided resort may well be had to interstate commissions, like the Palisades Commission and the proposed Joint Metropolitan Sewerage Commission.

GRAVITY SWITCHING IN RAILWAY YARDS.

The movement of cars by gravity for the switching operations required in railway freight yards is an old idea, the main purpose of which is to reduce the amount of locomotive work and its expense, for ordinary yard switching is a class of work that does not conduce to economy of service. In this country, gravity switching has not, until recently, been regarded with much favor, except in the use of "assisting grades" in poling yards to facilitate the movement of cars after being started by the poling locomotive. Within the past few years, however, there has been a decided change of opinion in this matter, and it is now very generally held that gravity switching is the quickest and cheapest method of handling cars through large yards, and that if properly operated there will be less damage to cars and their contents than by other methods. A majority of the new important yards have been built with special regard to gravity switching.

Most of these yards are built for what is known as the "hump" or "summit" system, as distinguished from the plain gravity system. Where the ground at the site of a yard is on a slope, and the yard is used for switching in one direction only, the cars may be simply started by a locomotive at the upper end and run by gravity direct from the receiving track to the several classification tracks and thence to the departure tracks. This plan has been adopted abroad in some notable cases, but there are very few (if any) complete examples of it in this country. Where the yard grades are not suitable for this method of operation, an artificial summit (or "hump" or "camel-back") is formed by building an embankment having the necessary grades.

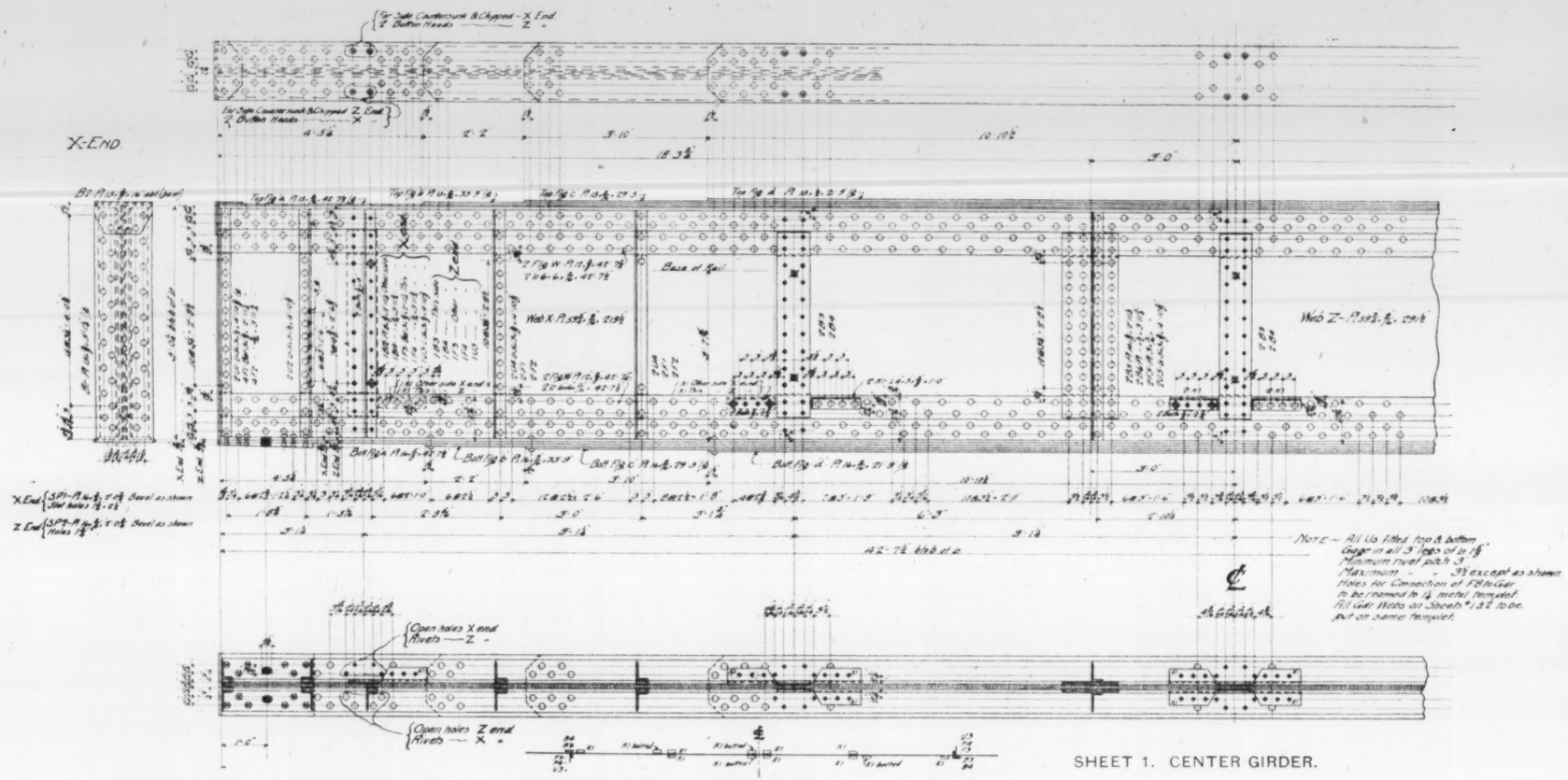
This latter method of gravity switching is of later date than the former, and is said to have been first employed in Germany about 1876; it is generally employed simply for the classification of cars, the bank and "hump" being located on the line of the track leading from the receiving yard to the classification yard. There is an easy grade on the ascending side (approached from the receiving yard), while on the descending side there is a short, steep accelerating grade, beyond which easier grades continue along the ladder tracks to the classification yard. A train of cars is pushed slowly over the summit, each car (or cut of cars) being uncoupled and acquiring an impetus on the accelerating grade which enables it to run onto its proper track in the classification yard; while a brakeman or car rider keeps the car under control so as to stop it at the desired point and to prevent damage due to cars being run together at too high a speed. The summit has usually one or two tracks, and connecting tracks on the yard level provide for the movement of cars or trains which do not reuqire to be switched for classification.

This gravity movement, however, does not complete the switching operation. To put the cars of any one track in the classification yard in proper order for outgoing trains, both as to order of destination and the grouping of air-b[rake]d "non-braked" cars, usually requires [con]siderable amount of shifting or drilling [by] engines. In order to economize in t[he] expense of this work it has been p[ro]posed the string of cars over a second [hump] gravity through a small sorting [yard] parture yard, in which the cars [are] the desired order. This has not [yet] garded with favor and there are [many] to it. It can, however, be adopted [only] on sloping ground, where the cars [run] continuously by gravity (under [control of] brakes) instead of having to be pu[shed] ond summit. It will be seen that [in] the hump system, the gravity mo[vement] one of a series of movements. A [car] on the receiving tracks by the [switch] pushed up to and over the summit [by a switch] engine, its cars then running by gr[avity onto their] destined tracks in the classificatio[n yard]. A second engine then drills the cars fro[m these tracks] into proper order for the outgoing [trains on the] departure track ready for the road engine.

In the plain gravity system, the entire series of movements through the yard is effected by gravity (under control of brakes) without the use of switching engines. As already noted, there are a few yards of this class abroad, but we believe there are none in this country, although (as noted below) there are some exceptional cases where the topographical conditions allow of classification movement without the use of the artificial "hump" grades. The first plain gravity yard was that at Edge Hill, near Liverpool (England), on the London & Northwestern Ry., which was built in 1873 to the designs of Mr. Footner, then Principal Assistant Engineer. It is probably the largest yard of the kind ever built, but it must be remembered that it is designed to handle mainly small four-wheeled cars, weighing (loaded) only about 15 to 20 tons. The same is true of other foreign gravity yards, and consequently they do not afford much assistance in the design of American yards handling cars 30 to 40 ft. long and weighing (loaded) perhaps 70 tons.

Bearing this in mind, however, it will be of interest to briefly refer to the Edge Hill yard, the operation of which is not generally understood. The main purpose of this yard is to receive the loaded cars gathered by switching or transfer engines from the various docks and shipping warehouses at Liverpool, and to make them up into trains ready to be taken on by the road engines. With the increase in traffic a great increase of yard facilities become necessary, but the situation was complicated by the fact that the yard was on sloping ground, the leveling of which would have been a costly undertaking. Mr. Footner, however, conceived the idea of utilizing the slope for gravity switching, and from the receiving yard the cars run to the separating yards, where each track receives the cars for a particular train. Beyond these are two classification yards or gridirons, through which the cars of each train are passed, so as to put them together in proper train order on the departure tracks below. The successive grades are as follows: Receiving yard, 1.07%; separating or sorting yard, 1.66, 1.43 1 and 1.56%; classification yards or gridirons, 1.27%.

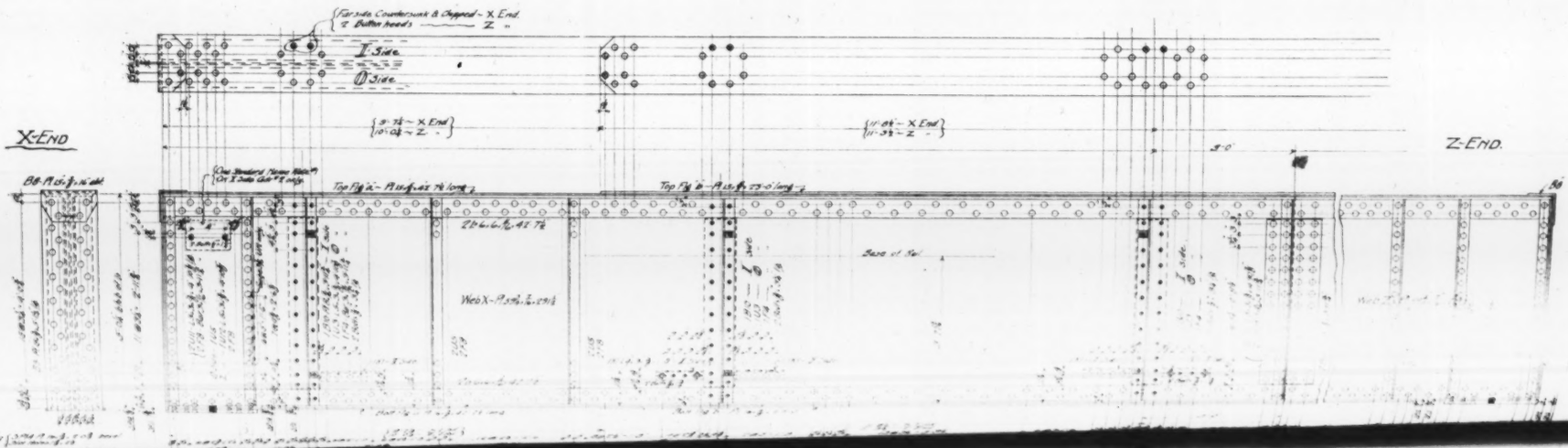
Reference has been made to the use of gravity switching in this country without the intervention of the artificial hump. One of the few examples of this is the Galewood yard (Chicago) of the Chicago, Milwaukee & St. Paul Ry., but here the gravity feature is mainly auxiliary to the ordinary poling system. The grade of the receiving tracks is 0.7% and the cars are started by a poling engine; the classification tracks have grades of 0.4% at the west end and 0.3% at the east end. For eastbound traffic the purpose of the yard is the opposite of that of the Edge Hill yard, as it is for breaking up instead of making up trains. At Galewood, the incoming eastbound trains are broken up, and cars classified by destinations; that is, the cars for each connecting road are put together on one track, and the same is done with cars for team tracks, freight houses, grain elevators, etc. The strings of cars are then

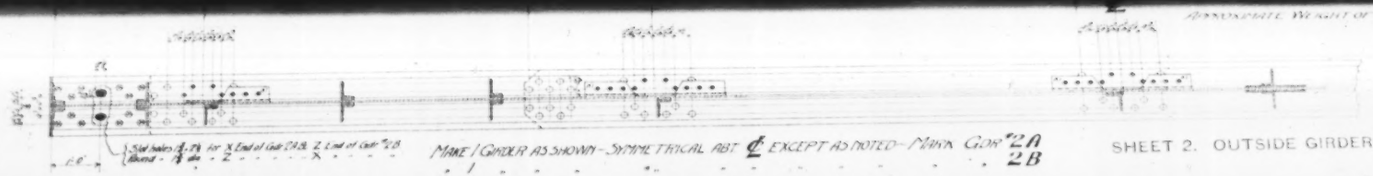

X-End
Z-End
Base of Rail
Open holes X and Rivets — Z
Open holes Z and Rivets — X
NOTE — All Up fillers top & bottom
Gage in all 3 legs of Ls 4"
Maximum rivet pitch 3"
Maximum — 3½ except as shown
Holes for Connection of FB to Gdr.
to be reamed to ¼ metal templet
All Gdr. Webs or Sheets ⅜ to be
put on same templet.

SHEET 1. CENTER GIRDER.

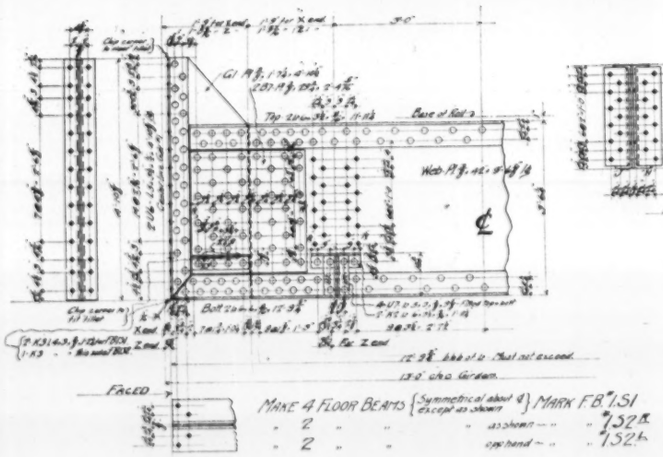
APPROXIMATE WEIGHT OF GIRDER ~ 12 TONS.

MAKE 1 GIRDER SYMMETRICAL ABOUT ℄ EXCEPT AS NOTED
MARK GDR. "1."

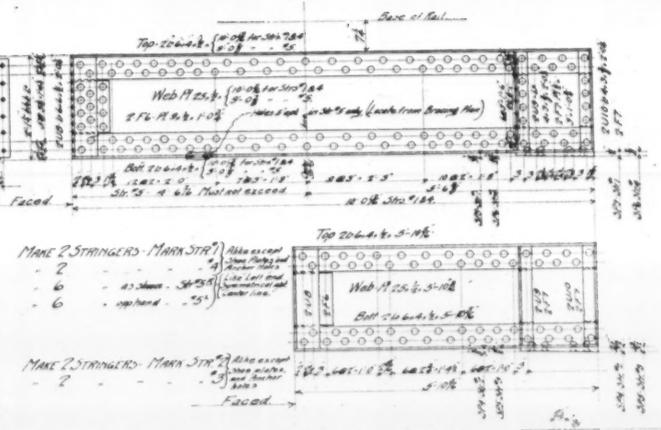


APPROXIMATE WEIGHT OF ONE GIRDER 8 TONS.

MAKE 1 GIRDER AS SHOWN - SYMMETRICAL ABT ℄ EXCEPT AS NOTED - MARK GDR "2A 2B

SHEET 2. OUTSIDE GIRDERS.

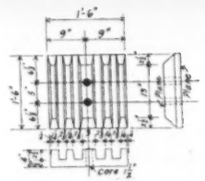


MAKE 4 FLOOR BEAMS {Symmetrical about ℄ / Except as shown} MARK F.B. "1.S1
- 2 - - - as shown - - - " 7.52 lb.
- 2 - - - opp hand - - - " 7.52 lb.

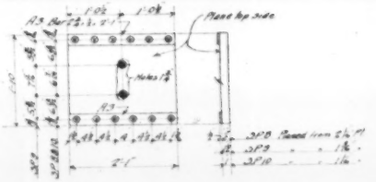


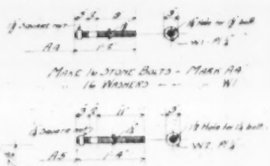
MAKE 2 STRINGERS - MARK STR "1
- 2 - - - Alike except Stem Plates and Anchor Plates
- 6 - as shown - STR "3
- 6 - opp hand - "

MAKE 2 STRINGERS - MARK STR "2
- 2 - - - Alike except Stem Plates and Anchor Plates

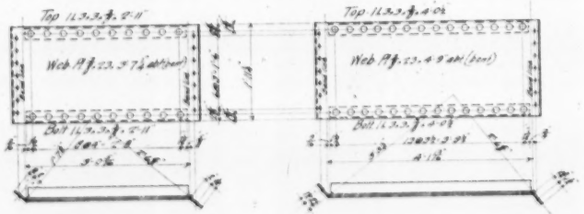


MAKE 8 SHOE PLATES AS SHOWN - MARK SP "7



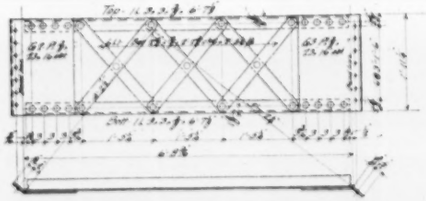
MAKE 2 SHOE PLATES - MARK SP "8
- 2 - - - SP "9
- 2 - - - SP "10

MAKE 16 STONE BOLTS - MARK A4
- 16 WASHERS - - - W1

MAKE 12 STONE BOLTS - MARK A5
- 12 WASHERS - - - W2

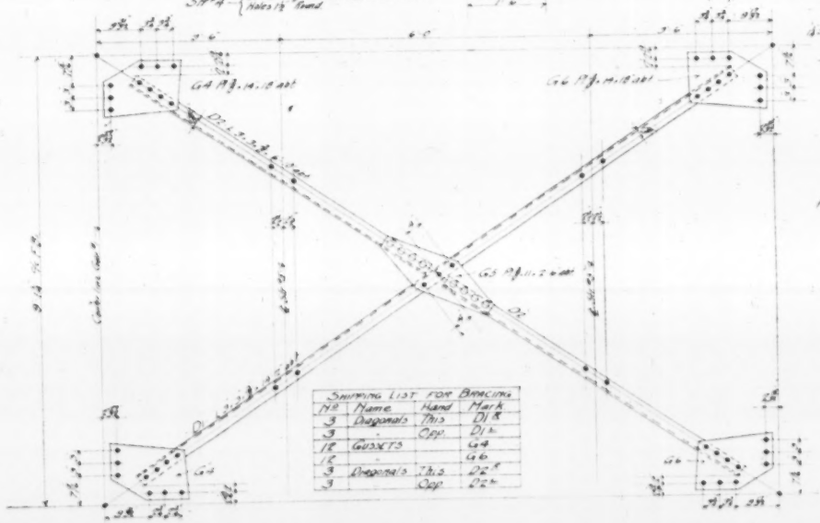


MAKE 4 END FRAMES - MARK EF "1

MAKE 4 END FRAMES - MARK EF "2 (LIKE EF1 EXCEPT AS SHOWN)



MAKE 4 END FRAMES - MARK EF "3



SHIPPING LIST FOR BRACING			
No	Name	Hand	Mark
3	Diagonals	This	D1 R
3	"	Opp	D1 L
12	Gussets		G4
6	"		G6
3	Diagonals	This	D2 R
3	"	Opp	D2 L

NOTE - Maximum Rivet Pitch 3"
Lap 1/4"
All Uprights fitted top & Bottom
Holes for connection of Stringers to F.B's & F.B's to Girders reamed to a metal template 1/4" thick

SHEET 3.
FLOOR BEAMS,
STRINGERS,
BRACING
AND DETAILS.

DETAILS OF A PLATE GIRDER BRIDGE, AS PLANNED FOR ECONOMY IN MANUFACTURE.

Illustrating "Shop Hints for Structural Draftsmen," by John C. Moses, M. Am. Soc. C. E.

by transfer or switch engines directly to these classification tracks for delivery to the outbound lines or to the proper tracks, as desired. Thus only one movement or classification is required, as against two at Edge Hill. The Galewood yard at Galewood has a grade of 0.7% for the receiving tracks, while the classification tracks are practically level.

The extensive use of the hump system of gravity switching for modern yards in this country has already been referred to, and one of the most difficult problems is the selection of the proper grades. There should be a slight ascending grade to the summit to close the cars together and facilitate uncoupling, and the first descending (or accelerating) grade must be sufficiently steep to give the car the necessary speed to carry it into the classification yard, with the assistance of an easier grade along the ladder track from which diverge all the parallel body or classification tracks. At the same time, the grade must not be so steep as to cause excessive speeds which will be dangerous for the car riders or for the cars and their contents.

The amount of elevation and the rates of grade required will vary with different kinds of cars and traffic handled, and also with varying climatic conditions. Thus, loaded cars will run more easily than empty cars, and the cars will run more easily in summer than in winter. The exact grades in any particular case, therefore, must be determined by experience with the class of business handled and the local conditions, and it is probable that in most new yards of this class the grades are gradually adjusted until the desired results are obtained. In fact, at a number of yards it has been necessary to raise the summit and increase the original grade. This is especially the case where the ladder tracks and classification tracks have low grades, as the irregularities of track and the numerous switch turnouts cause resistance which must be provided for by a proper arrangement of grades to keep the car moving at proper velocity. At Altoona, Pa., for instance, where the traffic consists largely of empty cars, the summit has been raised twice since its construction, and in other yards of the Pennsylvania R. R. the summits have had to be raised to give the cars sufficient velocity to carry them far enough along the low-grade classification tracks.

Gravity switching by the hump system has been the subject of investigation by the Yards and Terminals Committee of the American Railway Engineering and Maintenance of Way Association, and in a report presented at the recent annual meeting at Chicago it was shown that at a number of yards operated on this system the accelerating grades range from 1½ to 4% followed by grades of 0.3 to 1%. Mr. W. C. Cushing, Chief Engineer of Maintenance of Way of the Pennsylvania Lines, after an investigation of numerous yards, has recommended the following: (1) accelerating grade 3.5% from the summit if the length of this grade is only about 100 ft., or 1.5 to 3% if it is longer; (2) ladder tracks, 0.75 to 1.25% for loaded cars, or 1.25 to 1.5% for empty cars; (3) classification tracks, about 0.4%. If the descending cars are to be weighed by track scales, the grades should be reduced sufficiently to limit the speed of the cars to a maximum of about five or six miles an hour in passing over the scales; if this is not done, the speed must be reduced by applying the brakes. Where scales are used, Mr. Cushing recommends an initial accelerating grade of 2.5% for a length of 100 ft., or 2% for a length of 50 ft. As a rule the scale should be within 100 to 175 ft., from the summit, so that the cars will cross it before they have attained a high velocity. The conclusions of the above-mentioned committee in regard to the question of grade are as follows:

Where the cars to be classified are largely empty or light cars, the following grades are recommended for average conditions: 75 ft. of 1.5% up grade approaching summit; 300 ft. of 2.5% grade from the summit down, thence down through the several switches in the yard, 1%; thence down through the remainder of the yard, 0.5%.

Where the cars to be classified are largely loaded or heavy cars, the following grades are recommended for average conditions: 75 ft. of 1.5% up grade, approaching the summit; 300 ft. of 2% grade from the summit down; thence down through the several switches in the yard 0.7%; thence down through the remainder of the yard, 0.3%.

Where the traffic and climatic conditions require it, the grades should be made steeper in winter and restored again in the spring.

As an instance of the necessity of adapting the grades to the conditions of traffic, etc., it is noted by the committee that in one yard the grades may be different in the two humps for classifying traffic in opposite directions. Thus in the De Witt yard of the New York Central Ry., the westbound traffic includes many empty cars and is handled against the prevailing winds, while the eastbound traffic consists mainly of loaded cars. For the former (westbound) there is a grade of 4% for 150 ft. from the summit, followed by 1% for 1,200 ft. along the ladder tracks, while the classification tracks are on a grade of about 0.25%. For the latter (eastbound) there is a grade of 2.5% for 150 ft. from the summit, followed by 1% for 1,200 ft., beyond which the classification tracks are practically level. At the Elkhart yard of the Lake Shore & Michigan Southern Ry., where the traffic is more evenly balanced than in the De Witt yard, the grades are as follows: For westbound traffic, 4% from the summit, and 2% and 1% for the two diverging ladder tracks on opposite sides of the classification yard; for eastbound traffic, 4% from the summit and 1% on the ladder tracks. In a very few cases the one "hump" track is used for traffic in both directions, which involves pushing each train up a heavy grade. Thus the Winnipeg yard of the Canadian Pacific Ry. has a grade of 3.7% on each side of the summit, but we are informed that this has not been satisfactory.

The locomotives employed in hump switching have to exert a powerful and steady pushing force in putting long trains over the summit, working largely to their full capacity, and then returning for another load. They should, therefore, be of greater size and power than ordinary yard switching engines, which have to make continual to-and-fro short movements in drilling or poling a few cars at a time. This latter class of service is not conducive to economical operation, or to economy in repairs of either the locomotives or the yard tracks. In many cases the "hump" engines are of the consolidation (2-8-0) type, but the Lake Shore & Michigan Ry. has introduced special locomotives of great size for pushing heavy trains over the summits in the new gravity yards. These engines are of the decapod (0-10-0) type, weighing 135 tons (without tender), and have a tractive power of 57,600 lbs., as compared with 28,000 to 38,000 lbs. for the engines in other modern yards. The advantage of the more powerful engine lies in being able to handle a much greater number of cars at each operation. Thus at yards where these engines are used the trains pushed over the hump average 75 to 80 cars, and have reached a maximum of 130 cars. At other yards, the maximum is usually 60 to 70, with 35 to 45 as an average. At one yard the regular 85-car trains are broken in two for handling over the hump, although an 80-car train is occasionally handled entire.

LETTERS TO THE EDITOR

The Expansion and Contraction of Continuous Rails.

Sir: It would be of interest to see a discussion in your columns on the continuous rail of the type adopted by the best practice in street railway work and to know what means is used, if any, for taking care of expansion and contraction in long rail sections.

The writer had an opportunity to observe one break in a continuous rail where the ends of the fractured section separated about ¼-in. This fracture did not occur in the weld, as might have been expected, but was about 0.2 ft. from the ends of the welded bars.

Assume the welding to have been carried on during cool weather when the rails were at about 40° F. so the maximum change in temperature would occur in the winter when they would drop to say 10° F. The contraction of a rail section 2,500 ft. long would be 2,500 × .0000067 (coef. of expansion of steel) × 50° = 0.8375 ft. If the above method is correct, is it right to assume that this contraction is taken care of by elongation of the rail section and by its creeping under the heads of the spikes as well as through the pavements that are built against it?

Yours truly,

A. E. Steere.

Albany, N. Y., March 13, 1906.

[If our correspondent will refer to our issue of Oct. 27, 1892, he will find there a complete editorial discussion of the temperature stresses and movements of a continuous rail embedded in street paving. It was published at the time that the first experiments on continuous rails were made public, and its accuracy and soundness has been well established, we believe, by the large experience since that time with street railway tracks having welded joints. We quote the following extract from that editorial:

Taking the modulus of elasticity of steel at 29,000,000 and its coefficient of expansion at 1-150,000 per degree Fahrenheit, we have the compression or tension in pounds per square inch produced by a heating or cooling of one degree:

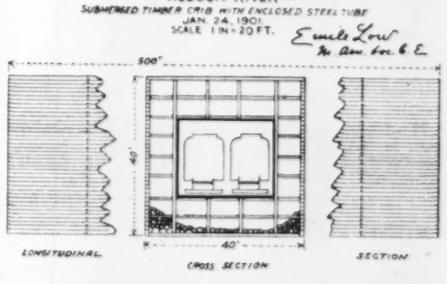
$$29{,}000{,}000 \div 150{,}000 = 193.$$

The temperature of the track when the shims were driven into the joints and the rigid splices were applied varied from 10° to 80°. If we take 40° as the average, we have a total variation of temperature of 80°. (The highest temperature of the rail during the summer was 120°.) Then 193 × 80 = 15,440 lbs. per sq. in. The cross section of the rail tested was about 7.6 sq. ins., hence the total compression of the rail when at the highest temperature was 15,440 × 7.6 = 117,344 lbs.

This is the compressive strain which will exist in a rail of this section of any length, short or long, which is heated 80° and absolutely prevented from linear expansion. The force which prevents this motion is the friction of the macadam roadway against the sides and bottom of the rail, and we may assume without much error that this is a constant amount per square inch of surface in contact. If we consider successive sections of the rail, beginning at one end, it is evident that the section at the end is under no strain, the next section is under a slight compression, the next under a greater and so until we reach a point where the full compression due to the tendency to expand will be exerted. By a little thought it will be seen that the compression at any point from the end until we reach this point of full compression will equal the total frictional resistance toward the end from this point. Since with the uniform friction per square inch which we suppose, the total resistance increases uniformly as we go from the end, we have a section of rail, extending from the end up to this point, in which the average compression is one-half that due to the increased temperature and the average expansion of which, therefore, is one-half that due to the increased temperature. In other words, on this end section of the rail up to the point where the resistance is great enough to stop all motion, we have on the average half the extension due to the given heating in a free rail and half the compression due to the given heating in a rail prevented from motion.

The Caisson System of Submarine Tunnel Construction in 1901.

Sir: Referring to the article on page 177, of your issue for Feb. 15, 1906, entitled "The Remarkable Tunnel Crossing of the Seine by Line 4, Metropolitan Railway of Paris," I would like to call your attention to the inclosed blue print, dated Jan. 24, 1901, over five years ago. At that time the Pennsylvania R. R. Co. was considering plans for crossing the Hudson River. This blue print and this proposed method of sinking the



cribs was submitted to Mr. Samuel Rea, Vice-President of the Pennsylvania R. R. My plan was to excavate a ditch, with a clam shell dredge, to the necessary depth, back-fill the same with rubble stone for a suitable depth, as now proposed for the Detroit River tunnel by Messrs. W. J. Wilgus and H. A. Carson, of the Advisory Board of Engineers, float the cribs in place and sink them. Of course the details were not all worked out, but the main idea is there.

Yours truly,

Emile Low, M. Am. Soc. C. E.

153 Lancaster Ave., Buffalo, N. Y., March 3, 1906.

A Tidal Lock in a Sea-Level Canal is Unnecessary.

Sir: History shows that sea-level canals without locks have always had an unfounded fear to overcome, of dire effects anticipated from the action of currents through them, before they could be constructed.

The construction of the Corinth Canal was thus prevented for 2,500 years after it was first projected.

The idea of the Suez Canal was denounced by leading

engineers of the day as an impossible work, if built without a tide-lock, and held up to the scorn and ridicule of men by these same engineers and by some of the greatest statesmen of that period as a bubble scheme, sure to bring ruin to all who would support it. It will not be improper to say at this point that now, 50 years later, it is paying 17 million dollars annually to its stock and bond holders, and a proposition to put a lock into it would be held as the suggestion of a maniac.

Undoubtedly the construction of the little, lockless, sea-level canal just completed in Tasmania, called the East Bay Neck Ship Canal, was preceded by predictions that the currents to be created in it, would saw the globe, which we inhabit, into halves, or else would wreck vessels that attempted to pass through it. Such are the usual accompaniments of such projects, and that they have not been wanting in the case of the Panama Canal, recent history plainly shows.

Would it be any different, if there were no Harlem River, and it were proposed to cut a canal from Hell Gate to the Hudson? Would it not be the same, if Long Island were joined to Manhattan, and it were proposed to cut a canal from off the Battery to Hell Gate? Unquestionably these projects would meet with these same objections. Engineers who think no further in the realms of practical hydraulics than to apply the ordinances of Kutter and eke of Chezy, would loudly object.

It requires, however, but a little exercise of the trained imagination on scientific lines to recognize that nature is much more resourceful than all that, and has repeatedly exhibited an adjustment of similar seeming unconquerable difficulties.

The Corinth Canal is only about 80 ft. wide on the water surface, but has been traversed by vessels of 42½ ft. beam, and drawing 20 ft.; while a newspaper account (New York "Tribune," March 18, 1906) gives the current through the canal as 3 knots per hour.

The complete data with regard to the Suez Canal are given in Annales des Ponts et Chaussees, 1898, 3e. Trimestre.

Briefly stated, there is a Red Sea tide at one end of the Suez Canal, of about 5½ ft., and two or three feet more than this during occasional Red Sea storms. That is to say, to be fair about it, the level of the Red Sea varies from a level of about 3 ft. above, to a level of about 3 ft. below, mean level of the sea; while 15 miles away, the Bitter Lakes hardly vary in level at all. There is thus produced a slope of water surface causing for six hours a current to the north, alternating with the same slope and a current to the south for another six hours, with a period of slack water, or of no current in either direction, in the middle of each six-hour period; and so on, like a huge teeter, 15 miles long, hinged at one end, in perpetual oscillation. These currents thus produced on a slope of 2¼ ins. to the mile of canal, attain a velocity at the four daily moments of greatest velocity of never over 2.67 ft. per second (1.6 knots per hour) in spring tides.

But be it noted: these currents, of no harm in themselves, are the creatures of but a moment. They begin to die, as they are born; that is to say, their death is fore-ordained with their gradual creation, lasting three hours, to take place within the following three hours. They begin from a slack-water, or no current, and requiring three hours to attain a maximum as given, they immediately slack off again during another three hours, until another slack-water is reached, and so on, making four times of slack-water every lunar day. So that it would be as true to state that there was *no* current in the canal, as it is to state only that the currents have a velocity of 1.6 knots, as is so frequently done.

The fancies of engineers and statesmen held with regard to it before its construction, have been nigh universally forgotten; but it is instructive to have them restated, that similar fancies held at the present day, and even of probable future recurrence, may be recognized as such, and rejected.

With this many-sided example given the world, it may seem strange that the same sort of history should at Panama have been allowed to repeat itself, with this difference: that so far the timid, doubting ones, have prevailed, but without grounds for their fears, stated in figures.

Some will tell you that they do not read French, and thus have not read, and cannot read, the history of the Suez Canal. Others find the propagation of wave water-levels outside of their equipment in studying hydraulic questions. And it may thus have come to pass that in the United States, in spite of many folios of reports published, no proper computation of the currents to be engendered in any proposed Panama sea-level canal have ever yet been printed, and presumably have never yet been made. It would undoubtedly require the work of one or two skillful hydraulic engineers for a month or more to make such a computation, but what is that to the capabilities of the United States Government, and in a cause of this sort? It is too much, however, to expect from the plain United States citizens as a volunteer offering; so that its absence in this article should be pardoned.

We have only these data: A slope of water surface on the Suez Canal of 2¼ ins. to the mile produced a maximum velocity of 2.67 ft. per second (1.6 knots); and it will not require profound hydraulic computations to show that, in a Panama Canal which would have a maximum slope of water surface of 3 ins. per mile on 44 or 45 miles of sea-level canal, the engendered velocities will not be inordinately great.

Again, the precise computations were long ago made by Boussinesq and other masters of the science of hydraulics, and may be found in the records of the meetings of the French Academy (Comptes Rendus) of 1887, volume 104, page 1484, for the cross-section of canal then proposed, and will not inordinately vary from this, for the cross-sections now proposed. The situation, as found by Boussinesq and his fellow-members of the Committee, would be exactly similar to the one above described as existing in the Suez Canal;—a long water surface, this time 45 miles long, hinged, as it were, at one end, and the other end oscillating some 10 ft. above and below the fixed mean level of the sea; making alternately a slope of water surface, and of currents to the north and to the south,—about 3 ins. to the mile of maximum slope, and maximum currents of about 4 ft. per second (2⅓ knots). On rare occasions during the year, brought about by strong gales, this may be exceeded, and there is room for the excess without materially obstructing navigation. Vessels do navigate channels having a 5-knot, 6-knot and higher velocity currents, up to 10 and 12 knots in narrow channels on river rapids. But it is not the purpose of this article to discuss debatable questions, and the precise limit of speed at which currents become of material hindrance to navigation, is such a question.

We have also the following, and there is reason for asserting that it required persistent effort to wring that much from the majority of a divided—undoubtedly compromising among themselves, very likely also overburdened—board of consulting engineers:

> The question of the necessity of a tidal lock at the Panama end of the canal has been raised by engineers of repute, but the limited time available to the Board has not permitted the full consideration of this question, which is desirable. It is probable that in the absence of a tidal lock the tidal currents during extreme oscillations would reach five miles per hour. While it might be possible to devise facilities which would permit ships of large size to enter or leave the canal during the existence of such currents, the Board has considered it advisable to contemplate and estimate for twin tidal locks located near Sosa Hill, even though the period during which they would be needed would probably be confined to a part of each spring tide.
>
> The highest recently recorded range of spring tides which the Board has seen [September, 1905] was 19 ft. 9 ins. between extreme low and extreme high water, while from 1882 to 1887 the highest amplitude reported was 20.93 ft. With such tides for a brief period at dead low water there would be a differential head of about 10 ft.—that is to say, the water in the can [45 miles away]* would be 10 ft. above that in the bay, while at extreme high water for a correspondingly short period the level of the water in the bay would be 10 ft. higher than that in the canal [45 miles away].*
>
> At the period of mean tide there would be no difference of level between the bay and the canal, so that during that period of the tide all the gates of the tidal lock could be open, leaving an unobstructed passage for vessels until the approach of the flood tide rendered it necessary for the gates to be closed until slack water would again be reached, and so on for each succeeding spring tide. During neap tides the range is so small that it will not be found necessary to bring the gates of the lock into use. Consequently, throughout the neap period of each tidal cycle a continuously open and unobstructed passage for traffic will be provided through the tidal locks.

All this errs, it is here argued, on the side of that safety which is the offspring of unfounded fear. In this there would be no especial harm, except that the proposition to handle huge lock-gates to control currents, is believed to be impracticable. It would also [illegible] the normal and balanced natural play of the [illegible] establishing harmless currents, throughout the [illegible] the canal, from the Atlantic to the Pacific. [illegible] also a restriction of the normal area of the body of the canal. For the water to pass through the [illegible] require an undesirable increase of the normal within the lock. But let all that also pass. [illegible] level canal could be built without a tide-lock [illegible] uniform cross-sectional area, without lack of [illegible] to the doubting; for a tide-lock could be added [illegible] time.

The world will probably never know what [illegible] delusion, at first presumably only an obiter [illegible] remark made without much reflection, that "[illegible] lock being a necessity, the addition of four others [illegible] less objectionable," on being officially promulg[illegible] President Shonts and then copied in magazine and [illegible] paper literature, had in determining the type of [illegible] to be constructed at Panama.

The object of this article and the point to be emphasized is the expression of the hope that [illegible] project for a sea-level canal will not be affected [illegible] the unwarranted assumptions of its opponents, [illegible] faint-heated support of its friends, as has been [illegible] of the Panama Canal and apparently of each of the [illegible] lockless sea-level canals now in existence; as [illegible] and faint-heartedness which before now have [illegible] prevented the construction of sea-level canals.

Clemens Herschel, Hydraulic Engineer.
2 Wall St., New York City, March 10, 1911.

*(Words in brackets have been added.)

SUMMIT OR HUMP YARDS FOR GRAVITY SWITCHING.*

The main functions of a railway yard are to receive trains passing over the road, to separate and classify the cars for their proper destinations, and to put the cars together into trains for forwarding. An important consideration is that this should be done in the most economical way, both as to time and cost, and the evidence at hand seems to show very conclusively that these results can best be attained in the "hump" type of yard. Its advantages may be summarized as follows:

Hump yards are very much more rapid in their work and in the handling of cars than any other types of yard in general use. If thoroughly equipped with engines of sufficient tractive power, humps of proper grades, enough riders to handle each cut of cars without delay, and a proper system of marking cuts and indicating to the switchmen where they go, the yard will not only work faster than any other type, but will do it at less cost, and with much less damage to the cars and to the merchandise handled in them.

A hump yard is one in which the movement of cars is produced by pushing them over a summit, beyond which they run by gravity. A train of cars is slowly pushed over the summit, each car or cut of cars being uncoupled and acquiring an impetus on the steep down grade which enables it to run onto the proper classification track by gravity without other assistance. A car rider or brakeman boards each car or cut of cars as it starts down the grade and controls it so as to stop it at the desired point on its track and to prevent damage due to cars being run together at too high a speed. The movement from the base of the summit may be facilitated

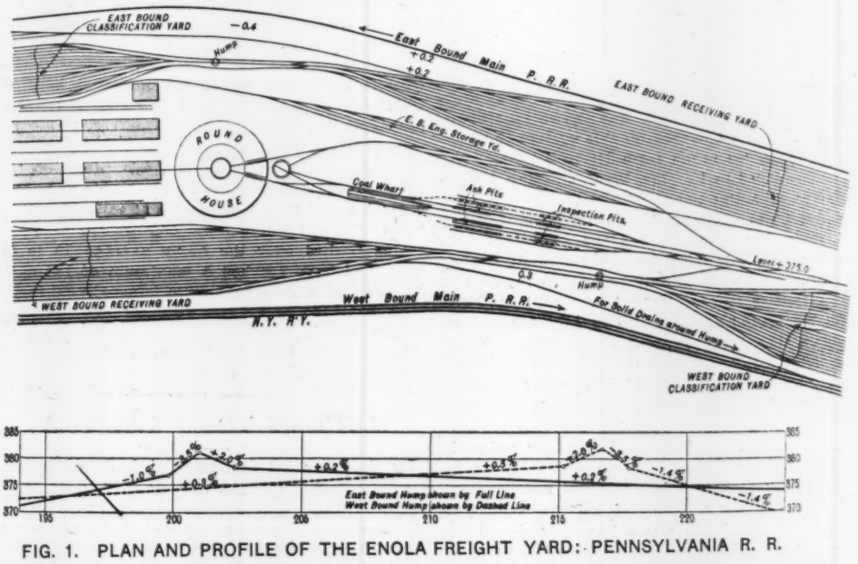


FIG. 1. PLAN AND PROFILE OF THE ENOLA FREIGHT YARD: PENNSYLVANIA R. R.

*Abstract of the report of the Committee on Yards and Terminals, presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association at Chicago, March 20, 22. The members of the committee are as follows: J. A. Atwood, E. E. Raftman, A. B. Corthell, E. P. Dawley, W. A. Garrett, H. Mann, J. D. Mason, I. G. Rawn, C. S. Sims, F. S. Stevens, J. E. Taussig.

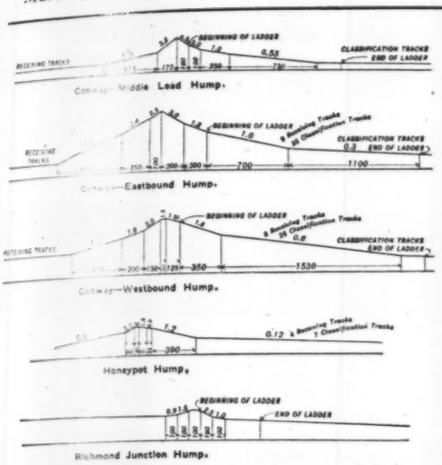


Fig. 2. Profiles of Gravity Switching Humps in Yards of the Pennsylvania R. R.

by an assisting grade. Connecting or run-around tracks provide for the movement of cars which do not require to pass over the hump.

The grade of the receiving tracks should be such that one engine can push the entire train over the hump, and the receiving tracks are connected with the classification tracks over the hump by switches in such a way that cars on any receiving track can be pushed over the hump into any classification track. The tracks approaching the summit should be on a slight up grade to ensure that the cars are closed up so that they can be readily uncoupled at the hump without causing delay.

Hump yards cannot be properly operated without riders on the cars, and in considering the accelerating grades for the hump this fact must be borne in mind. The descending or accelerating grades of the hump should be such that the cars will run by gravity from the summit to their proper destinations on the classification tracks. The exact grades must be determined by experience with the class of business handled and the local conditions. The amount of elevation and rates of grade required will vary with different kinds of cars and traffic handled, and also with the varying climatic conditions: that is to say, loaded cars will run more easily than empty cars, and the cars will run more easily in summer than in winter. It is desirable to keep the distance from the hump to the end of the switches as short as possible, and for this purpose the "double-V" shaped layout for switches is usually the best.

The cars on any one track in the classification yard are, as a general thing, not arranged in proper order for handling in trains, and a considerable amount of shifting has therefore to be done in order to put the cars in proper train order. It has been suggested that this part of the work might be greatly facilitated by passing the cars over a second hump into the departure yard, but the opinions received were almost unanimously opposed to the use of a second hump for this purpose.

The following arrangements of grades for hump yards, operating under different conditions of traffic and in northern and southern climates, have been suggested:

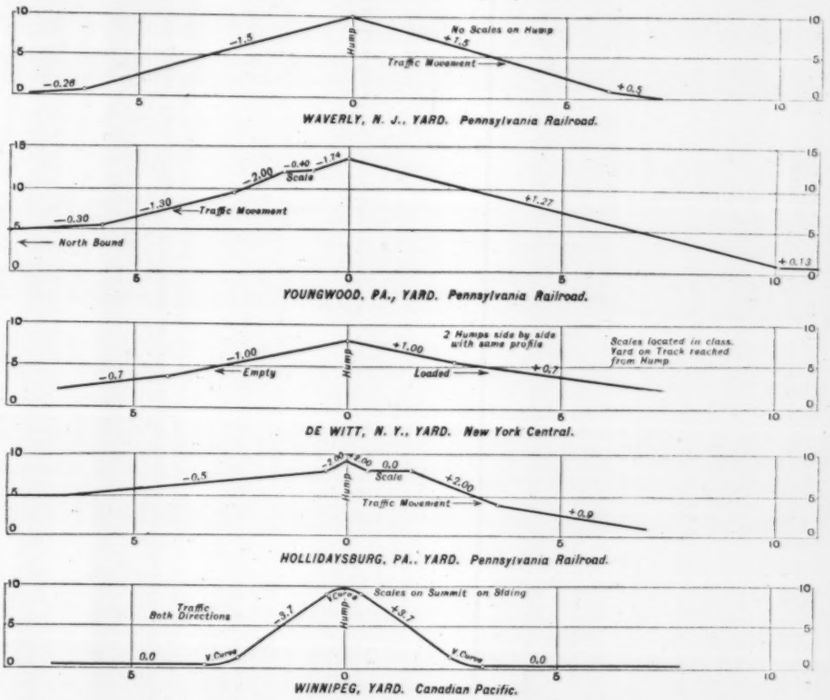


FIG. 3. PROFILES OF HUMPS OF GRAVITY SWITCHING YARDS.

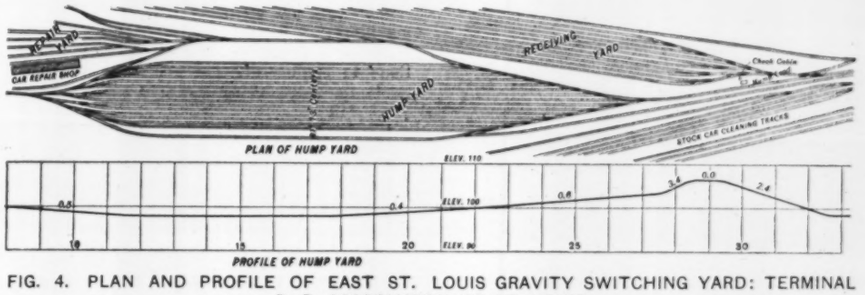


FIG. 4. PLAN AND PROFILE OF EAST ST. LOUIS GRAVITY SWITCHING YARD: TERMINAL R. R. ASSOCIATION OF ST. LOUIS.

The grades from the receiving tracks should be such that one engine could push the maximum train over the hump.

Classification tracks need not be full train lengths, except when used as departure tracks.

Departure tracks must be full train length and of sufficient number to provide ample standing room for trains while being tested for air and while waiting for engines. The departure yard should be provided with an air hose and air brake testing plant.

	Northern Climate.	Southern Climate.
1. Bunching grade, Approaching summit.	75 ft. of 1.5% up grade.	75 ft. of 1.5% up grade.
2. Momentum grade (no scales on hump tracks):		
A. For loaded cars,	200 ft. of 3% down grade.	200 ft. of 2.5% down grade.
B. For empty cars.	200 ft. of 4% down grade.	200 ft. of 3.0% down grade.
3. Momentum grade (with scale on hump).	25 ft effective of 4% followed by scales on 1% followed by easy vertical curve, say 50 ft. in length, followed by 200 ft. of 3% down grade for loaded cars or 200 ft. of 4% down grade for empty cars.	25 ft. effective of 2.5% followed by scales on 1% followed by easy vertical curve, followed by, say, 200 ft. of 2.5% down grade for loaded cars or 200 ft. of 3% down grade for empty cars.
4. Ladder grade:		
A. For loaded cars,	0.9% throughout.	0.7% throughout.
B. For empty cars,	1.2% throughout.	1.0% throughout.
C. For yards handling both loads and empties.	1.2% throughout.	1.0% throughout.
5. Continuing grade through yard:		
A. For loaded cars,	0.3%.	0.2%.
B. For empty cars.	0.4%.	0.3%.

CONCLUSIONS.—A hump yard is the best form of yard for receiving, classifying and making up trains, because cars can be handled through it faster, with less damage and at less cost than through any other form of yard.

Hump yards should consist of receiving, classification and departure tracks, in consecutive order as enumerated.

Receiving tracks should be of sufficient length to hold a maximum train, and of sufficient number to hold a number of trains arriving in quick succession. The number will depend on the amount and character of traffic handled, and upon the relative location of the yard with respect to other yards and connections.

Grades after leaving the summit should be such as to carry the cars to their proper destination in the yard, and where the traffic and climatic conditions require it, the grades should be made steeper in winter and restored again in the spring.

Where the cars to be classified are largely empty or light cars, the following grades are recommended for average conditions: 75 ft. of 1.5% up grade approaching summit; 300 ft. of 2.5% grade from the summit down; thence down through the several switches in the yard, 1.0%; thence down through the remainder of the yard, 0.5%.

Where the cars to be classified are largely loaded or heavy cars, the following grades are recommended for average conditions: 75 ft. of 1.5% up grade, approaching the summit; 300 ft. of 2% grade from the summit down; thence down through the several switches in the yard, 0.7%; thence down through the remainder of the yard, 0.3%.

When required, scales should be located at such a distance from the summit (75 ft. is recommended) that when the car to be weighed reaches the scales it will be properly spaced from the following cars and running slowly enough to render correct weighing easy.

For averaging conditions it is recommended that a No. 9 frog be the sharpest used for classification yards, making the angle of the body track with the ladder that of a No. 7 frog.

EXAMPLES OF YARDS.

EIKHART AND COLLINWOOD YARDS (Lake Shore & Michigan Southern Ry.).—These are among the most recent of large hump yards, and are notable for the enormous engines used. Each of these yards has two humps, and the grades for each hump are as follows: East-bound, 0.83% for approach, 0.85% to summit, 4% accelerating grade, and 1% on the leads to the classification tracks. West-bound, 0.85% for the approach, 2% to the summit, 4% accelerating grade, and 2% and 1% for the two leads on opposite sides of the classification yard. One engine (0-10-0 type) of 135 tons is used for each hump, having a tractive power of 57,000 lbs. As an average there are nine riders to each hump (nine by day and 11 at night at Collinwood). The switches are operated by hand, with three switchmen to each hump.

HAWTHORNE YARD (Chicago, Burlington & Quincy Ry.).—The grade of the hump at the steepest part is 3.2%, and length of hump proper is about 250 ft. The ladder has a grade of about 0.5% and is about 500 ft. long. Two engines are used in classifying cars over the hump, working from 9 a. m. to 9 p. m. A scale is located on the hump and cars are weighed when switched. The tractive power of the engines is 28,200 lbs. each. Eight men are employed as riders. The switches are operated by hand; three switchmen are employed with the engine—two to throw switches and one to uncouple cars on the hump. There are 20 tracks in the classification yard.

EAST ST. LOUIS YARD (Terminal Railway Association of St. Louis).—The hump yard is located at East St. Louis, parallel with and next to the receiving yard. One engine is used in classifying cars on the hump. The tractive power of the engines is 34,000 lbs. About 14 car

riders are employed when business is heavy, and from 11 to 12 when business is light. The switches are operated by hand. Three switch tenders are employed to throw the switches. There are 16 tracks in the classification yard. The length of these tracks is about 1,500 ft.

DEWITT YARD (New York Central & Hudson River Ry.).—The grades of the two humps in this yard are different for east-bound and west-bound traffic. For the west-bound traffic, which includes many empty cars and is handled against the prevailing winds, there is a grade of 4% for 150 ft. from the summit, then 1% for 1,200 ft. through the ladder tracks, while the remainder of the classification tracks are on a grade of about 0.25%. For the east-bound traffic, which consists mainly of loaded cars, there is a grade of 2.5% for 150 ft. from the summit, followed by 1% for 1,200 ft., beyond which the classification tracks are practically level.

NONCONNAH YARD (Illinois Central Ry.).—The accelerating grades of the hump and ladder are as follows: 275 ft. of 2%, 100 ft. of 1%, 500 ft. of 0.2%. One 96-ton engine is used in pushing trains over the hump. Five men are employed as riders and two as switchmen, the switches being operated by hand. There are seven tracks in the classification yard.

The arrangements of grades at some important gravity yards operated on the summit or "hump" system are shown in Figs. 1 to 4, which are selected from those given in the committee's report. As to the speed of operation in yards of this type we have tabulated some of the figures given, as follows:

	Elkhart, L. S. & M. S. Ry.	W. Albany, N. Y. C. Ry.	Hawthorne, C. B. & Q. Ry.	Haselton, P. & L. E. Ry.
Maximum cars per train over hump	130	80	30	44
Average " " " "	70 to 80	45	.....	35
Average number of cuts per train	60 West. bd. 40 East. bd.	.....	20	14
Average time for classifying maximum train	9 cuts in 10 mins.	.....	15 mins.	15 mins.
No. of cars passed over hump in 24 hours	1,600 to 2,900	1,680 to 2,800	400	987

JOHN JAMES ROBERTSON CROES.

The many friends of this prominent American Hydraulic Engineer and Past President of the American Society of Civil Engineers will be grieved to learn that he died at his residence in Yonkers, N. Y., on Saturday, March 17, after a brief illness.

Mr. Croes was born in Richmond, Va., Nov. 25, 1834. His father was a clergyman of the Protestant Episcopal Church, and his grandfather, John Croes, was the first Protestant Episcopal Bishop of New Jersey. His maternal grandfather was James Robinson, a banker, of Philadelphia and Richmond, and after these two grandfathers Mr. Croes was named.

Mr. Croes' early boyhood was passed in Terre Haute, Ind., to which place his father had removed in 1843; and in 1853, he was graduated from the College of St. James, near Hagerstown, Md. After graduation, Mr. Croes took up the study and practice of engineering—as was then the custom, in the offices of practicing engineers; one of his preceptors being the late Samuel McElroy, of Brooklyn. After some service with the New Jersey Railroad & Transportation Co., he assisted in the construction of the Ridgewood reservoir of the Brooklyn Water-Works, under the late James P. Kirkwood, as Chief Engineer. In 1860, on the completion of the Brooklyn work, he was engaged, under Gen. George S. Greene, on the new Central Park reservoir of the Croton Water-Works, and the High Bridge enlargement of the same; he became Resident Engineer of this work, when Gen. Greene was called to the front in the Civil War. In 1863, Mr Croes became Assistant Engineer on the Washington Aqueduct, under the Department of the Interior; and had charge of the completion of the Cabin John Bridge, the aqueduct and the Great Falls dam.

In 1865, he was called to Cincinnati and St. Louis, in connection with investigations conducted by Mr. Kirkwood; but in December of the same year he returned to New York to take charge of surveys for the construction of storage reservoirs in the Croton Valley. The construction of the Boyd's Corner's Dam, the first high masonry dam built in the United States, was one of the results of Mr. Croes' report upon this valley. For a paper upon this dam, presented to the American Society of Civil Engineers, in 1874, Mr. Croes was awarded the first Norman Medal.

From 1872 to 1878, Mr. Croes was in the service of the Department of Public Parks of New York, as Principal Assistant and then Chief Engineer of the Topographical Bureau of the Department. Mr. Croes did most efficient work in surveying and laying out the street system of the then newly annexed district, now known as the Borough of the Bronx. Together with Frederick Law Olmstead, the landscape engineer of the Department, a joint report and plans were submitted, which were approved by the Commissioners and the public, and the actual work of carrying out these plans was commenced by Mr. Croes. Messrs. Olmstead and Croes also submitted plans for rapid transit in this district; and Mr. Croes was the Chief Engineer of one of the lines suggested—the Suburban Rapid Transit Co., which constructed its elevated road in 1883-1891.

Mr. Croes was later connected with many important engineering investigations; and for a more detailed list of these the reader is referred to the extended biography of Mr. Croes, published in Engineering News, Jan. 17, 1901, on the occasion of his election as President of the American Society of Civil Engineers. It is sufficient here to note among these—The Croes and Howell Report of 1879 on the water supply of Newark, N. J.; the Syracuse report of 1889; his services on the commission on the plan and location of the proposed Quaker Bridge Dam, on the Croton River; his report on the water supply of New York City to the Merchants' Association, in 1900; and a similar report made in the previous year to the Controller of New York.

Mr. Croes has contributed largely to engineering literature in the form of papers and discussions before engineering societies and contributions to engineering journals. In 1881-86, he wrote for Engineering News historical and statistical descriptions of the water-works of over 800 American cities; and the principal statistics, along with others obtained later, were published in book form as "The Statistical Tables of American Water-Works." After three editions this work, in altered form, was continued as "The Manual of American Water-Works," under the editorship of Mr. M. N. Baker. Mr. [illegible] much for the editorial columns of "[illegible] Engineer," in 1880-90, and for "The [illegible] zette," in the latter discussing and [illegible] traffic on the elevated railways of [illegible] City, for which purposes he had ga[illegible] of valuable statistics.

Mr. Croes was made a Member of [illegible] Society of Civil Engineers, Dec. 4, [illegible] Director in 1876; Treasurer in 187[illegible] President in 1888, and was the Pres[illegible] society in 1901. He was also a M[illegible] Institution of Civil Engineers, of L[illegible] American Water-Works Association, [illegible] England Water-Works Association, [illegible] American Public Health Association, [illegible] the Union League and Century Clu[illegible] York City. In 1895 he was appointed [illegible] ernor of New York a member of a co[illegible] devise plans for the preservation of [illegible] on the Hudson River.

Mr. Croes ended his long and useful professional life literally in the harness; to within a few days of his death he was actively employed as engineer of the Carnegie Lake and Bridges at Princeton University, at Princeton, N. J.

SINGLE-PHASE ELECTRIC EQUIPMENT FOR THE NEW YORK TERMINAL DIVISION OF THE NEW YORK, NEW HAVEN & HARTFORD R. R.

Within the past year the New York, New Haven & Hartford R. R. decided to operate its New York terminal and suburban traffic by electricity. The direct motive for the decision was, no doubt, the fact that the New York Central & Hudson River R. R. was actively engaged in a similar transformation of its terminal and suburban service to operation by electric motive power, under the pressure of legislative enactment calling for electric motive power in the Park Ave. tunnel.

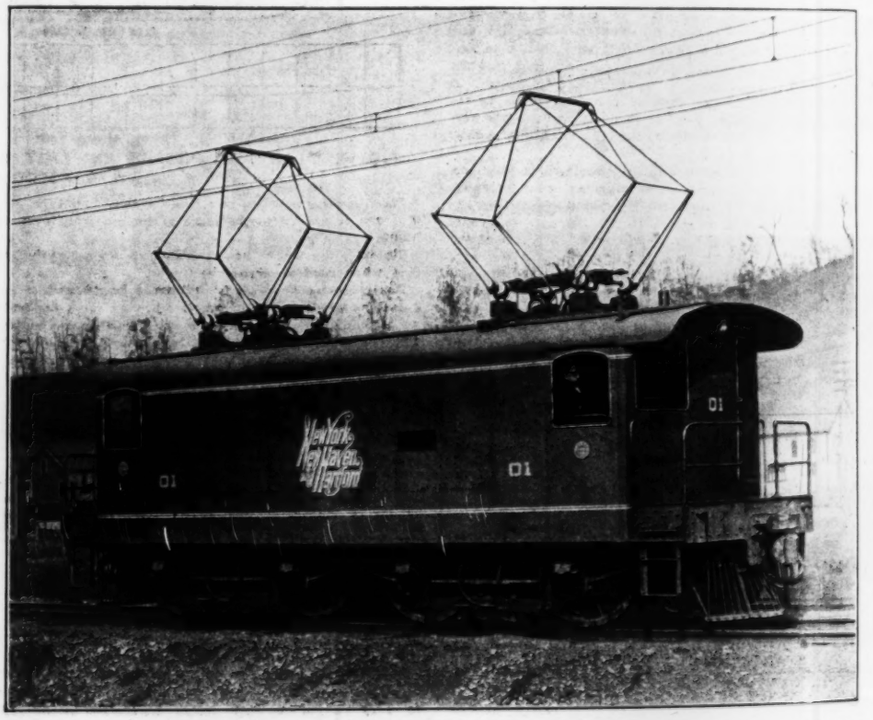


FIG. 1. VIEW OF 11,000-VOLT SINGLE-PHASE ELECTRIC LOCOMOTIVE FOR THE TERMINAL DIVISION OF THE NEW YORK, NEW HAVEN & HARTFORD R. R.

As the New Haven uses the New York Central's tracks for entry into New York City (12 miles from Woodlawn, on the northern boundary of New York City, to the Grand Central Terminal), the inauguration of electric terminal service by the latter would require the New Haven either to install electric service of its own or else to

have its trains hauled over the joint terminal section by the New York Central's electric locomotives.* The former alternative was chosen. In planning for its execution, the New Haven took the view previously taken by the New York Central, namely, that if the trackage within the limits of New York City had to be operated by electric traction, it would be advantageous to extend the electric service throughout the zone of suburban travel; anything less, indeed, would be seriously disadvantageous both in economy and in operating convenience.

and is without doubt a very important contribution to electric locomotive design.

The external appearance of this locomotive is well shown in Fig. 1 herewith. As clearly appears, the machine is carried on two four-wheel trucks. The wheels are 62 ins. in diameter; the truck wheel-base is 8 ft. and the distance between truck centers is 14 ft. 6 ins., making the total wheel-base 22 ft. 6 ins. All wheels are drivers. Each of the four axles carries a motor rated at 250 HP., making the total power of the

will be lubricated to permit a perfectly free motion in curving. Fig. 2 shows a truck complete but without the motors.

Owing to the fact that the entire space between the wheels is occupied by the motors it was impossible to transmit the drawbar pull through the center line of the locomotive in the usual way. Instead of this, strong plate girders heavily cross braced are carried outside of the wheels and the entire strain of the drawbar is carried to these through strong box girders having top and bottom places 42 ins. wide. Directly underneath the girder at

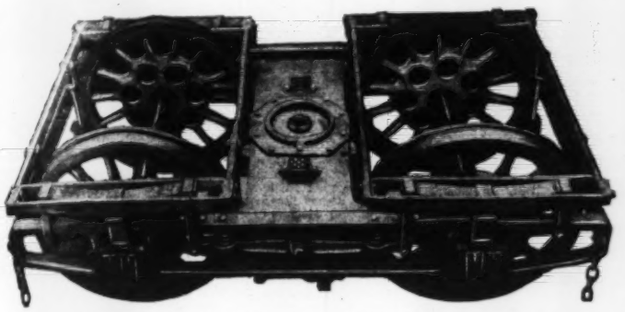


FIG. 2. TWO-MOTOR TRUCK FOR NEW YORK, NEW HAVEN & HARTFORD SINGLE-PHASE LOCOMOTIVE.

FIG. 3. ARMATURE, QUILL AND DRIVING FLANGES, NEW YORK, NEW HAVEN & HARTFORD SINGLE-PHASE LOCOMOTIVE.

A few months ago it was announced that the New Haven officials had selected for this terminal service the single-phase alternating current system, using series (commutator) motors. As the New York Central is installing a direct current system, this unexpected step aroused unusual interest. The single-phase series motor being able to operate with direct current, at the cost of but slight complication of the controlling mechanism, no essential incompatibility was involved. But the characteristics of the single-phase traction system are such that its adoption leads quite naturally to an installation differing radically from a direct-current installation in almost every respect. Instead of the low line-voltage (500-650 volts) used for direct current, a high voltage (11,000 volts in the case of the New Haven) is used on the line-conductor. Instead of the third-rail required by the large currents of the direct-current railway, the high voltage and low current of the single-phase line call for an overhead trolley wire. The power-transmission problem is entirely changed in aspect, because the absence of rotary converter substations in the alternating current system makes three-phase transmission unnecessary, and at the same time the high trolley voltage makes it possible to feed long sections of line from a single power station without substations. These differences and the fact that single-phase traction has not yet had opportunity to show its merit in commercial heavy railway service, lend an exceptional interest to the details of the New Haven electric equipment.

The first description of details of the New York, New Haven & Hartford electric equipment was given last week by Mr. B. G. Lamme, of the contractor for the work, the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., in a paper read before the New York Railroad Club at New York City. The paper revealed little of novelty in its purely electrical phases, if we except from this statement the employment of the high potential of 11,000 volts on the trolley wire on so important and congested a line as the one in question. The nature and arrangement of motors, controllers, overhead conductors and supports, current collectors, etc., are substantially identical with those embodied in previous installations of the single-phase series system by the Westinghouse company on various suburban electric "trolley lines." The principal novelty is found in the locomotive, which is of striking originality

*Reference to a comprehensive description of the work in progress on the terminal section of the N. Y. C. & H. R. R. R., in Engineering News of Nov. 16, 1905, will further explain the situation. In that article is also shown a map of the terminal lines of the New York Central, which will give the relative location of Woodlawn, the junction point of the two roads. The New Haven's suburban traffic extends, roughly, as far as the Connecticut state line, about 13 miles east of Woodlawn

locomotive 1,000 HP., on the one-hour rating. The locomotive is able to handle a 200-ton train in local passenger service on a schedule speed of 26 miles per hour, stops about 2 miles apart, which requires a maximum speed of about 45 miles per hour. In through service it can handle a 250-ton train. Its tractive effort is about 5,000 lbs. when running at 60 miles per hour, and 20,000 lbs. at the maximum. For heavier service two locomotives may be double-headed, and for this purpose they are fitted with multiple unit control apparatus, using the Westinghouse air-operated electrically controlled unit switches.

The frame, trucks and cab of the locomotive were built by the Baldwin Locomotive Co. on designs developed after many conferences between the New Haven railway company, the Baldwin Locomotive Co. and the Westinghouse Electric & Mfg. Co. The design adopted was partially determined by the fact that the motor equipment must be suitable for use on both alternating and direct current. This to a certain extent controlled the number and size of the motors and thus affected the construction of the trucks and other parts. The results have

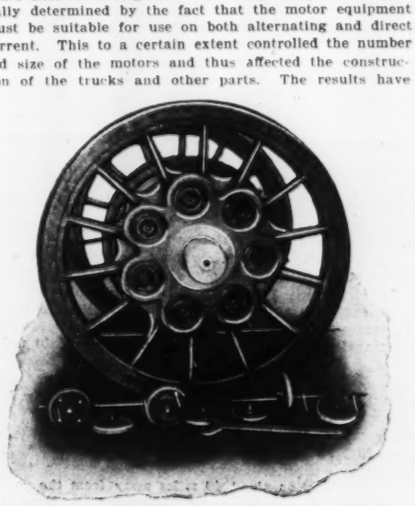


Fig. 4. Outside View of 62-in. Driving Wheel, New York, New Haven & Hartford Locomotive.

turned out so well, however, that there is every reason to believe that this type of locomotive will be used in future even where alternating current alone is used.

The side-frames of the trucks are of forged steel; the pressed steel bolster carrying the center plate is bolted and riveted to the side frames. The weight on the journal boxes is carried by semi-elliptic springs with auxiliary coiled springs under the ends of the equalizer bars, to assist in restoring equilibrium. The bolsters are 30 ins. wide at the center plate, and where bolted to the side frames they are widened to nearly double this amount, thus giving a very strong construction without excessive weight. The center plate which transmits the tractive effort to the frame is 18 ins. in diameter and

each end is a Westinghouse friction draft gear to which the drawbar is attached. The entire design lends itself to a very strong construction without great weight. The cab is built up of sheet steel on a framework of Z-bars. The apparatus inside the cab is carried on a framework of structural steel which is built into the cab and firmly anchored to floor and ceiling. Over each motor is a large trap-door which permits easy access to motor bearings, brushes, etc.

The mounting of the motors, and their driving connection to the running gear, are particularly novel. Quill mounting is used, with flexible direct connection to the drivers, thereby eliminating all gears and at the same time avoiding the accumulation of nonspringborne weight on the axles. Figs. 2, 3 and 4 explain the construction. The armature is shown in Fig. 3, as assembled on its quill, but with a lathe mandrel inserted in place of the axle. At either end of the quill is a driving flange carrying seven outward projecting driving pins, arranged in a circle concentric with the armature. These pins engage spring-pockets formed on the inner face of the wheel hub, shown in Fig. 2. Each pocket is bushed with a renewable steel bushing, in which is seated an irregularly coiled spring, surrounding a steel sleeve on the driving pin. The successive coils of this spring are eccentric in different directions, the result being that the driving-pin is spring-cushioned in the pocket in all directions. It has a play of $\frac{3}{8}$-in. each way before coming to solid bearing, or a total range of motion of $\frac{3}{4}$-in. The springs are strong enough to carry the entire weight of the motor, but normally this is carried by the suspension springs of the field-frame, so that the driving-springs have only to transmit the driving torque to the wheels and keep the motor axis parallel with the axle. The quill has about $\frac{5}{8}$-in. clearance (on each side) on the axle; the driving-pins will, therefore, come to bearing before the quill touches the axle.

End-play of the motor is also taken care of in the driving pockets. The driving pins are hollow and contain a coil spring which bears against a screw cap forming the outside wall of the pocket (Fig. 4).

On each end of the armature quill, just inside of the driving flange, is formed a journal which rests in an armature-shaft bearing in the motor case or field frame. The frame is split horizontally and can be removed in halves, to give access to the inside of the motor. It is suspended by four coil springs from a steel bar frame resting on the axle-boxes. The torque on the motor frame is taken by a set of horizontal parallel-rods which anchor it to the truck above and below the axle; these rods permit vertical and side motion of the motor, against its springs, but protect the driving-pin springs from bumping stresses.

The motors are substantially the same as the single-phase motors which the Westinghouse company has been building during several years past for interurban service, except that, due to their low speed, the New Haven motors have exceptionally low commutator speeds, less than 3,000 ft. per min. at 60 miles per hour. The four motors are connected permanently in pairs. The normal voltage at the terminals (of the pair) is about 450 volts alternating and 550 to 600 volts direct current. As already noted, they have a one-hour rating of 250 HP. each; their continuous capacity is over 200 HP. per motor, or over 800 HP. for the locomotive. This exceptionally high ratio of continuous to rated capacity is secured by air-blast cooling. A motor-driven blower in the engine cab supplies air for cooling the motors, transformers and rheostats. The air enters the motor at the end away from the commutator, and leaves by grated openings in the field frame. Besides its cooling effect, the air blast is advantageous in maintaining a slight plenum in the motors, tending to keep out dust, snow, etc.

When running on alternating current the motors are controlled by voltage control, by means of taps on the secondary of the transformer which reduces the line-potential of 11,000 volts to the proper voltage for the motors. For better weight distribution, two transformers are used, one placed on either side of the cab. Each feeds one pair of motors, through its own set of unit switches. Six main secondary taps are provided on each transformer, and a number of intermediate ones to aid in passing from one working point to the next.

On direct current the motors are controlled by the usual series-parallel method with the help of resistances. A special feature, however, is the use of shunt resistance to weaken the field, for the higher speeds. It is stated that the motors permit almost indefinite shunting of the field without affecting the commutation; this is taken advantage of to obtain several of the speed steps before passing to parallel connection of the two pairs of motors.

Besides the necessary auxiliaries, such as oil circuit breakers, motor-driven air compressors for brakes, etc., and motor-driven blowers for cooling, the cab contains a steam boiler for furnishing steam for heating the train.

The current collectors for alternating current are two "pantagraph" bow trolleys, each of which is sufficient to carry the entire current required for the locomotive. On the direct-current terminal section, eight third-rail shoes, four on each side, collect the current; these are of such design as to be able to make contact either with the New York Central's bottom-contact third-rail or with an ordinary top-contact third-rail. As there are also some points, such as crossings, on the direct-current section where the break in the third-rail is bridged by a section of overhead conductor, a separate overhead contact arm, also of the pantagraph form, is provided for this service.

The contact line and current supply system is, electrically, of the simplest possible nature. The generating station produces single-phase alternating current at 11,000 volts pressure directly from the generators, i. e., without raising transformers, and sends this current into the overhead trolley wires of the several tracks and into a pair of feeder wires carried along in parallel the full length of the electric division. No transformer stations are used, and no transmission line other than the feeder wires and the trolley-wires themselves.

The power house is located on the shore of Long Island Sound, 3 miles west of Stamford, Conn. (the eastern end of the electric division), and 19 miles east of Woodlawn. As at present planned it is to be equipped with steam-turbine alternator units each of 5,500 KW. capacity three-phase or 3,750 KW. single-phase. These units, running at 1,500 r. p. m., are of rather remarkable design electrically:

The generators have two poles and at 1,500 r. p. m. give 3,000 alternations per minute or 25 cycles per second. A 5,500-KW., three-phase, bipolar, 1,500 r. p. m. generator would have been considered an impossibility only a short time ago. The design of these generators was one of the difficult problems in this undertaking. The difficulty, however, was in designing the machines in the first place, and after a suitable construction was worked out, the manufacture of these machine appears to be comparatively easy. The machines have an ample margin, both electrically and mechanically, and they are particularly well adapted for handling inductive loads. As an illustration of unusual conditions met with in the design of such machines, I will mention that a single complete armature coil weighs about 600 lbs. However, as the machines have only two poles, the total number of armature coils is relatively small. As a machine in such service is liable to have rather severe short circuits at times, the armature end windings are extremely well braced.

As these machines are to feed directly into the trolley system, they are wound for the normal trolley tension of 11,000 volts, and in consequence one terminal of each machine is always grounded when in service, as in usual practice with D. C. railway generators. This point has been fully kept in mind in the design of these machines.

As the New Haven railway company contemplates operating certain existing D. C. systems from this power house it was decided to add an additional leg to the armature winding so that three-phase currents could be obtained for feeding into rotary converter stations for furnishing direct current for some D. C. lines which, at the present time, cannot be conveniently changed to straight A. C. The New Haven company also has other fields for three-phase power which it proposes to take care of as soon as it is feasible to do so.

The trolley line is of the "double catenary suspension" form. Each trolley wire is hung from two messenger cables which span about 300 ft. between supporting bridges and are pulled up to a sag of about 6 ft. The trolley wire is attached by triangular supports every 10 ft.; it is 22 ft. above the rail. The bridges carrying the wires are steel structures similar to signal bridges; at intervals of about two miles a heavier anchor bridge is provided.

The overhead system is designed to be amply safe under abnormal conditions, such as high wind or heavy coating of ice. The stresses in the supporting cables with a load of ice ½-in. thick, or 1 in. total, on the cables, hangers, etc., will be about one-sixth of the ultimate. The stresses in the structure due to wind have been figured on a basis of 16⅔ lbs. per sq. ft. projected surface for the cables and 25 lbs. per sq. ft. for flat surfaces. This is on a basis of the cables being covered with ice as given above. Allowance is made for double these pressures in summer when there is higher wind velocities, but under this condition the cables will be of much smaller diameter in the absence of ice.

Two feeder wires run along the side of the overhead work, the full length of the line. These are fed in parallel with the trolley wires. At points corresponding to the anchor bridges each trolley wire is divided by a section insulator, and each section is connected to the feeders and to the other trolley wire sections by automatic circuit-breakers. In case of accident any section, of one or more tracks, can be cut out without disturbing the supply to any of the other sections.

As 11,000 volts is used on the trolley system, no transforming stations are necessary on the part which is now to be installed. The high voltage trolley system will extend about 19 miles in one direction from the power house and about 3 miles in the opposite direction to Stamford. This system could be extended in the latter direction approximately 20 miles further, if desired, without transforming substations. Therefore about 40 miles of the trolley system can be supplied directly from the main power house. With a locomotive load representing 4,000 KW. about 19 miles from the power house and a corresponding load 15 miles away, or 4 miles from the power house, the drop at the end of the line will be about 13%. This drop is on the basis of feeding into the load from one direction only. If there were a transforming substation about 40 miles away from the power house, feeding into the same trolley system, then the drop at a point 20 miles away would not be 13%, but would be considerably less as power would be supplied from both directions. It is apparent therefore, that with sub-stations along the line feeding into a common trolley system, such substations could be possibly 60 miles apart. For example, if a transforming substation were placed in New Haven, about 40 miles away from the power house, the drop at the midway point between the substation and power house would be equivalent to a load on the present system at 10 to 15 miles from the power house.

The first locomotive built to the designs adopted for the New Haven work was completed at the East Pittsburg shops of the Westinghouse Electric & Mfg. Co., some time ago and has been running in continued trial service since then on a one-mile section of track in the yard. About 2,000 miles have been run up now, and very satisfactory performance is reported.

NATIONAL ADVISORY BOARD ON TESTS OF FUELS AND STRUCTURAL MATERIALS.

The following is the list of members appointed by President Roosevelt to the National Advisory Board on Tests of Fuels and Structural Materials. This board, as many of our readers will recall, is to have direction of the various tests of fuels and materials to be conducted by Government expense at the laboratories now in operation at St. Louis, Mo.:

From the American Institute of Mining Engineers:
John Hays Hammond, Past-President, Empire Building, New York.
Robert W. Hunt (of Robert W. Hunt & Co., Testing Engineers, Chicago, Pittsburg and New York), Chicago, Ill.
B. F. Bush, Manager and Vice-President, Western Coal & Mining Co., St. Louis, Mo.

From the American Institute of Electrical Engineers:
Francis B. Crocker, Professor of Electrical Engineering, Columbia University, New York.
Henry C. Stott, Supt. Motive Power, Interborough Rapid Transit Co., New York.

From the American Society of Civil Engineers:
C. C. Schneider, President; Chairman Committee on Concrete and Reinforced Concrete, Pennsylvania Bldg., Philadelphia, Pa.
George S. Webster, Chairman Committee on Cement Specifications; City Engineer, City Hall, Philadelphia, Pa.

From the American Society of Mechanical Engineers:
W. F. M. Goss, Dean of the School of Engineering, Purdue University, Lafayette, Ind.
George H. Barrus, Steam Engineer, Pemberton Square, Boston, Mass.
P. W. Gates, 210 State St., Chicago, Ill.

From the American Society for Testing Materials:
Charles B. Dudley, President, Altoona, Pa.
Robert W. Lesley, Vice-President, Pennsylvania Bldg., Philadelphia, Pa.

From the American Institute of Architects:
George B. Post, Past-President, 33 East 17th St., New York.
William S. Eames, Past-President, Lincoln Trust Building, St. Louis, Mo.

From the National Brick Manufacturers' Association:
John W. Sibley, Treasurer Sibley-Menge Press Brick Co., Birmingham, Ala.
Wm. D. Gates, American Terra Cotta & Ceramic Co., Chicago, Ill.

From the National Fire Protective Association:
O. U. Crosby, Chairman Executive Committee, 76 William St., New York City.

From the National Lumber Manufacturers' Association:
Nelson W. McLeod, President, Equitable Building, St. Louis, Mo.
John L. Kaul, President Southern Lumber Manufacturers' Association, Birmingham, Ala.

From the Corps of Engineers, U. S. Army:
Lieut.-Col. Wm. L. Marshall, Army Bldg., New York.

From the Isthmian Canal Commission:
Lieut.-Col. O. H. Ernst, Washington, D. C.

From the Bureau of Yards and Docks, U. S. Navy:
Civil Engineer Frank T. Chambers, Washington.

From the Supervising Architect's Office, U. S. Treasury Department:
James K. Taylor, Supervising Architect, Washington.

From the Reclamation Service, U. S. Interior Dept.:
F. H. Newell, Chief Engineer, Washington, D. C.

From the American Railway Engineering and Maintenance of Way Association:
H. G. Kelley, President, Minneapolis, Minn.
Julius Kruttschnitt, Director of Maintenance and Operation, Union Pacific R. R., 135 Adams St., Chicago, Ill.
Hunter McDonald, Past-President; Chief Engineer Nashville, Chattanooga & St. Louis Ry., Nashville, Tenn.

From the American Railway Master Mechanics Association:
J. F. Deems, General Superintendent of Motive Power, New York Central Lines, New York.
A. W. Gibbs, General Superintendent of Motive Power, Pennsylvania R. R., Altoona, Pa.

From the American Foundrymen's Association:
Richard Moldenke, Secretary, Watchung, N. J.

From the Association of American Portland Cement Manufacturers:
John B. Lober, President, Land Title Building, Philadelphia, Pa.

From the Geological Society of America:
Samuel Calvin, Professor of Geology, University of Iowa, Iowa City, Ia.
I. C. White, State Geologist, Morgantown, W. Va.

From the Iron and Steel Institute:
Julian Kennedy, Metallurgical Engineer, Pittsburg, Pa.
C. S. Robinson, Gen. Mgr. Colorado Fuel & Iron Co., Denver, Colo.

From the National Association of Cement Users:
Richard L. Humphrey, President, St. Louis, Mo.

From the National Board of Fire Underwriters:
Chas. A. Hexamer, Chairman Board of Consulting Experts, Bullitt Building, Philadelphia, Pa.

AN OPEN DRAWBRIDGE ACCIDENT occurred at Chicago on March 14 and narrowly escaped being serious. A crowded four-wheel street car of the Union Traction line approached the temporary pontoon draw-span at North Ave. just as the bridge was being opened. The motorman (an extra man) tried to stop the car with the hand brake, but the car slid on the slippery rails and went off the end of the approach. The bridge tender had seen that the car could not stop and checked the bridge so that the front end of the car landed on the pontoon, while the rear end remained on the approach. Several passengers were badly shaken and bruised by the shock.

THE POLLUTION OF THE DELAWARE RIVER has been made the subject of a conference between Governor Stokes, of New Jersey, and Governor Pennypacker, of Pennsylvania, together with a representative of the New Jersey Sewerage Commission, the Health Commissioner and other state officers of Pennsylvania. The decision reached at the conference was that the states of New York, New Jersey and Delaware should take joint action to remedy existing and to prevent additional pollution of the river. Governor Stokes has sent a letter to the New Jersey Legislature stating the above facts, and suggesting that the New Jersey Sewerage Commission, or its representative, be authorized to meet representatives of Pennsylvania and New York for the purpose of devising legislation to the end stated, for presentation to the New Jersey Legislature of 1907. Governor Stokes called attention to the fact that the Delaware drains 32% of the land area of New Jersey, on which resides a population of 415,000, or nearly one-fifth of the entire state.

AN ASPHALT PLANT FOR WALKS AND CROSSings at Kingston, Ont., has been operated by the city for twelve years past. The main features of the plant are a 40-gal. asphalt boiler, a 100-sq.-ft. sand-heater, and a mixing board of the same size. The sand-heater is a ¼-in sheet iron plate, resting on 12-in. brick walls 2 ft. high, the walls enclosing an oven. This plant cost $105, and it is covered by a shed 20 × 30 ft. in plan. To operate the mixing plant three laborers are required; to prepare the foundation and lay the asphalt four laborers are employed; in addition there is one carter. The laborers are paid from $1.30 to $1.57 per day and the carter is paid $2.25 a day, making a daily labor charge of $12.74, not including the time of the general street foreman. In 1905 there were laid 5,000 sq. ft. of asphalt crossings, at an average cost, for labor and material, of 9.577 cts. per sq. yd. Planks from old walks were used for fuel, without charge except for cartage. Mr. H. B. R. Craig is city engineer of Kingston, Ont., and the foregoing information has been taken from a paper recently read by him before the Canadian Society of Civil Engineers.

COMPLETE INDUCTION MOTOR EQUIPMENT of a new 2,000,000-bushel grain elevator of the New York Central & Hudson River R. R. at Weehawken, N. J., includes motors aggregating about 3,200 HP. in capacity. All operate on 550-volt 25-cycle three-phase current supplied by a generating station in a building separate from the elevator; they are started and stopped from a switching room on the ground floor of the elevator. The equipment comprises the following motors: one 40-HP. for pulling railway cars into the elevator and spotting them on the receiving tracks; two 40-HP. for operating the 32 power shovels in the receiving hoppers; eight 100-HP. for the eight receiving elevators; seven 40-HP. for seven compound-shake double Howe cleaners on the ground floor; one 60-HP. operating a 60-in. Sturtevant exhaust fan, and three 40-HP. operating a 55-in. and two 60-in. discharge fans of the dust-collecting system; seven 100-HP. for seven cleaning elevators; eight 100-HP. for eight shipping elevators; one 40-HP. for the marine leg elevator (7,500 bushels per hr.); two 40-HP. operating eight 22-in. cross conveyor belts; one 75-HP. operating a 36-in. longitudinal belt conveyor (reversible, 10,000 bushels per hr.; 6-800 ft. per min); one 40-HP. for a screening elevator; one 5-HP. operating a Deane automatically controlled drainage pump in the basement; one 10-HP operating a Rumsey centrifugal pump as drainage auxiliary; one 10-HP. motor operating a 1-ton Morse & Williams freight and passenger lift. All the motors drive their machines by rope transmission, using a total of about five miles of ⅞-in. and 1-in manila four-strand rope made by the Plymouth Cordage Co. The motors are started in the switching room upon receiving a push-button signal from an elevator attendant at the motor. Another button at the motor is arranged to trip an individual oil-switch in the switching room, for stopping the motor. The signals are operated by 15-volt alternating current supplied by a small transformer in the switching room. Two compensators for starting the motors are fitted on a separate panel in the switching-room; each is capable of starting four motors simultaneously, although generally only one will be started at a time. All the motors are of dust-proof design. Several of the rooms in the elevator are heated by electric heaters. Lighting is done by 115-volt 16-c.p. alternating-current lamps inside, and 32-c.p. lamps outside the building. The electric equipment, including motors, lighting and accessories, was furnished by the General Electric Co.

PERSONALS

Mr. Edward P. Byrne has been re-elected City Engineer of Medford, Mass.

Mr. W. J. Parkes, of Bessemer, Ala., has been elected City Engineer of Pine Bluff, Ark.

Mr. O. Offerdahl, of Seattle, Wash., has been elected City Engineer of Sedro Woolley, Wash.

Mr. George H. Penglase has been appointed General Master Mechanic of the MacArthur Brothers Co., with headquarters at 810 Fisher Building, Chicago.

Mr. C. H. Blackman has resigned as Assistant Engineer of the Louisville & Nashville Railroad Co., at Pensacola, Fla., to accept a position in the office of the Chief Engineer at Louisville, Ky.

Mr. L. W. Berry, Division Superintendent of the Chicago, Burlington & Quincy Ry., at Beardstown, Ill., has been appointed Superintendent of Transportation of the Toledo, St. Louis & Western R. R., with headquarters at Frankfort, Ind.

Mr. F. P. Gutelius, Engineer of Maintenance-of-Way, of the Canadian Pacific Ry., has been appointed Assistant Chief Engineer of that railway, with headquarters at Montreal, Quebec. He will be in charge of engineering and maintenance on the eastern lines.

Mr. G. A. Anderson, Superintending Engineer, has been appointed Consulting Engineer for Railways at Madras, India, and Mr. R. R. Gales, Executive Engineer, has been appointed Engineer-in-Chief of the Bombay-Sind Connection Railway Survey, with the rank of Officiating Superintending Engineer.

Mr. Tyrrell B. Shertzer, Assistant Engineer in the Third Division, Board of Rapid Transit Railroad Commissioners, New York City, has resigned this position to accept the position of Resident Engineer on the reconstruction of Vaughn's Bridge, under the Portland Bridge District, at Portland, Me.

Mr. Otis C. Loomis, for the past three years Assistant Engineer in the City Engineer's Office, at Altoona, Pa., has resigned to enter into a partnership with the firm of Henry & Dillman, Civil and Mining Engineers, Altoona, Pa. The firm hereafter will be known as Henry, Dillman & Loomis, Civil and Mining Engineers, with offices at 47-49 Altoona Trust Building, Altoona, Pa.

Mr. George Sydney Binckley, Consulting Engineer, Mills Bldg., San Francisco, formerly Chief Engineer and Constructor of the works of the Puyallup River hydro-electric power development for the Puget Sound Power Co., near Tacoma, Wash., has accepted the position of Chief Engineer and Manager of Construction for the installation of complete systems of water supply, sewerage and electric street railways for the city of Monterey, Mexico, where he has assumed charge of the work.

Mr. A. L. Hertzberg, Division Engineer of the Ontario Division of the Canadian Pacific Ry., will succeed Mr. F. P. Gutelius as Engineer of Maintenance-of-Way, with office at Montreal, Que. Mr. J. M. R. Fairbairn, Division Engineer of the Eastern Division, has been appointed Division Engineer of the Ontario Division at Toronto, Ont., in place of Mr. Hertzberg. Mr. J. H. Barber, Division Engineer of the Atlantic Division, at St. John, N. B., has been appointed to succeed Mr. Fairbairn as Division Engineer, at Montreal.

Mr. John Cook, Assoc. M. Inst. C. E., City Engineer of Cape Town, Cape Colony, S. A., has been awarded nominal damages in a suit for libel brought by him against a representative of a paving company. The jury decided that the plaintiff had overstepped the limits of fair criticism in certain letters to the local press alleging that the city engineer had discriminated against pavement in which the plaintiff was interested. The judge ruled that each side should pay his own costs, as there was, in his opinion, no serious defamation of character.

Lieutenant-Colonel Daniel C. Kingman, Corps of Engineers, U. S. Army, has been transferred from duty at Cleveland, O., to Savannah, Ga. Other recent changes in the Corps of Engineers are as follows: Major Hiram M. Chittenden, from Sioux City, Ia., to Seattle, Wash. Lieutenant Ernest D. Peek, from Cincinnati, O., to the Yellowstone National Park. Lieutenant Henry C. Jewett, from Fort Leavenworth, Kan., to Boston, Mass. Lieutenant Arthur Williams, from Fort Leavenworth, Kan., to Cincinnati, O. Lieutenant Gustave R. Lukesh, from Boston to New London, Conn.

Mr. A. E. Kimberly has been appointed Special Assistant Engineer under R. Winthrop Pratt, Chief Engineer of the Ohio State Board of Health. Mr. Kimberly, who has been for the last two years connected with the Columbus, O., sewage testing station, will be assigned to the work of making examinations of existing sewage disposal plants. These examinations are to be made in accordance with a recent act of the Ohio Legislature directing the State Board of Health to investigate the construction, methods of operation and efficiency of all sewage and water purification plants in the state.

Recent changes in the personnel of the U. S. Geological Survey, Department of the Interior, have been made, as follows: Mr. R. W. Berry, topographer, having finished his work with the Panama Canal Commission, has been assigned to duty on the Louisville, Ky., quadrangle. Mr. C. H. Birdseye, topographer, transferred from California to work in Pennsylvania. Mr. J. I. Gayetty, topographer, from work in Oregon to office work on West Virginia sheets. Mr. A. P. Meade, topographer, from Arizona to office work in Washington. Mr. L. E. Tucker, from work in California to office work in Washington. Mr. T. M. Bannon, topographer, who has been in charge of field work in Arizona, has been transferred to Washington for office work on the quadrangles in Wyoming mapped under his supervision last summer.

Obituary.

Dennis le Duc, a Canadian engineer and builder of railroads, died recently after a long illness, at Los Angeles, Cal.

Elbert Suedeker, at one time a leading building contractor, died on March 9 at his home in Brooklyn. He was born in Oyster Bay, N. Y., 64 years ago, and was one of the organizers of the Brooklyn Elevated Railroad Co., and its first Vice-President. He leaves a widow and a daughter.

Joseph Cabot Foster, an architect and engineer, died at his residence, 112 Bridge St., Salem, Mass., on March 8, after a long illness. He was born in Salem on June 29, 1829, and was educated in the public schools of that city. He was the Street Commissioner of Salem for many years. After retiring from this position he opened an office as an architect, in which profession he continued until last January.

John Warner Henderson, a member of the firm of Henderson & Co., Ltd., of Philadelphia, Pa., died on March 11 at his home at Wyncote, Pa., of diabetes. Mr Henderson was born in Philadelphia in 1860. He was graduated from the University of Pennsylvania in 1880. For several years he was Superintendent of the Wharton Swith Co. Later he became a member of the firm of Macy, Henderson & Co. This firm afterwards changed to the Henderson Company, Ltd.

Cornelius J. Ryan, a building contractor, of New York City, formerly a member of the firm of Ryan & McDonald, died in St. Louis, Mo., on March 13 of a complication of diseases. He had completed many large contracts in various parts of the United States. Among them were the Baltimore tunnel, the Fourth Avenue tunnel, in New York City, and many large undertakings for the West Shore and the Delaware, Lackawanna & Western Railroad companies. Since the completion of Mr. Ryan's work in the construction of the Croton Dam, which began in 1892 and ended in 1900, he had practically retired from active business.

Samuel O. Howe, Treasurer of the Chicago & Northwestern Ry., and of the Chicago, St. Paul, Minneapolis & Omaha Ry., died suddenly of heart disease on March 17 on the Ninth Ave. elevated station at Christopher St., New York City. He was on his way from his home, 40 West 126th St., to his office, 52 Wall St. He had been in good health until two years ago, when he began to suffer with heart trouble. A son, Russell G., and four daughters survive him. He belonged to Lafayette Post, G. A. R., and the St. Nicholas Society. Mr. Howe was born in New York City in 1842. Thirty-five years ago he entered the service of the Chicago & Northwestern Ry. in New York as a bookkeeper.

John Price, City Engineer and Surveyor, of Birmingham, Warwickshire, England, died on March 6 at Burnham, following an operation for appendicitis and peritonitis. He was 51 years old. He was educated at the Manchester Grammar School and the Victoria University, where he obtained the Ashbury prize for civil engineering. From 1871 he practiced engineering in several cities until he was appointed in 1896 to the office of City Engineer and Surveyor at Birmingham, succeeding Mr. W. S. Till, retired. Mr. Price was a member of the Institute of Civil Engineers, a fellow of the Surveyors' Institute, and a member of the Council of the Board of Examiners of the Incorporated Association of Municipal Engineers. He had served as President of the Birmingham Association of Engineer Students, and he was a Vice-President of the Municipal Officers' Association. Mr. Price, who resided in Chantry Road, Moseley, leaves a widow, one son and two daughters.

Casper Teiper, President of the Buffalo Structural Steel Co., of Buffalo, N. Y., died on March 8 of paralysis, after an illness extending over 17 years. He was born in Westphalia, Germany, in 1846, and came to the United States in early boyhood. He was educated in Detroit, Michigan, and New York City. In 1870 he began his career in civil engineering, with the Kellogg Bridge Co., then a prosperous business enterprise in Buffalo. In 1878 he assumed the management of the Hamilton Bridge Co., of Hamilton, Ontario. Mr. Teiper superintended the construction of many important steel and iron bridge structures throughout the country. In 1891 he moved to Buffalo, and with Mr. Carl Meyer started the Buffalo Bridge & Iron Works. Later he built the plant at Black Rock, known as the Buffalo Structural Steel Co. He is survived by his wife, Agnes M.; one daughter, Grace J., and three sons, Harry C., Edward J., and Frederick. He was buried at Holy Cross Cemetery, Buffalo.

Charles Edward Perry, a well-known Canadian civil engineer, died at St. Luke's Hospital, Ottawa, Ontario, on March 15. When a young man he was connected with the construction of the Intercolonial Railway. He was one of the engineers in the construction of the Canadian Pacific, where he worked chiefly in the west, and for some time resided in Victoria, B. C. He remained active in his profession until seized with heart disease three

months ago. At that time he was District Engineer of District E., of the Transcontinental Railway construction force, with headquarters at Nipigon. He was also engaged at the time in the construction of the Trans-Canada line. He had wide acquaintance and many friends in every province, and had become most experienced in his profession. He was a member of the Canadian Society of Civil Engineers, and of the Institute of Civil Engineers of England. Mr. Perry was prominent in military circles and was graduated from Ottawa University, and from the Royal Military College of Kingston. He was born in Borrisokane, County Tipperary, Ireland, on July 25, 1843. When a young man he came to Canada and lived many years in Ottawa. His father, Lieut.-Col. Perry, was a well-known civil engineer and military officer, and was at one time City Engineer of Ottawa.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 20-22. Annual meeting at Chicago, Ill. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago, Ill.
AMERICAN RAILWAY ASSOCIATION.
April 25. Semi-annual meeting at Chicago, Ill. Secy., W. F. Allen, 24 Park Place, New York City.
AMERICAN ELECTROCHEMICAL SOCIETY.
May 1 to 3. Annual meeting at Ithaca, N. Y. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 1 to 4. Semi-annual meeting at Chattanooga, Tenn. Secy., F. R. Hutton, 12 West 31st St., New York City.
NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 5. Annual meeting at Atlantic City, N. J. Secy., W. C. L. Eglin, 136 Liberty St., New York, N. Y.
AMERICAN FOUNDRYMEN'S ASSOCIATION.
June 5 to 7. Annual convention at Cleveland, O. Secy., Richard Moldenke, Watchung, N. J.
AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 18. Annual convention at Atlantic City, N. J. Secy., J. W. Taylor, Old Colony Bldg., Chicago, Ill.
AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 26. Annual convention at Thousand Islands, N. Y. Secy., Chas. Warren Hunt, 220 West 57th St., New York, N. Y.

AMERICAN MOSQUITO EXTERMINATION SOCIETY.—The preliminary program has just been issued for the third annual convention of this society, which is to be held at the Aquarium, Battery Park, New York City, on April 11, 2.30 p. m. Papers are expected from Dr. L. O. Howard, Chief Entomologist, Dept. of Agriculture, Washington, D. C.; Dr. C. B. Davenport, Carnegie Institute, Cold Spring Harbor, N. Y.; Dr. Quitman Kohnke, Prest. New Orleans Board of Health; Prof. C. H. Townsend, Director New York Aquarium; Col. W. C. Gorgas, U. S. A., Chief Sanitary Officer Panama Canal Zone; Dr. A. H. Doty, State Health Officer of the Port of New York; F. C. Beach, New York, N. Y., and L. D. Baker, Jr., of Boston, Mass. The advisory board of entomologists will submit "The Mosquito Brief." Secy., H. C. Weeks, Bayside, L. I., New York City.

WEST VIRGINIA GOOD ROADS ASSOCIATION.—This society was organized at Wheeling, March 15, in connection with a state convention to discuss highway improvement. The officers elected were Jas. H. Stewart, of Morgantown, President; J. W. Wier, Elkins, Secretary, and H. C. Frauzheim, Wheeling, Treasurer. A convention will be held at Charleston during the next session of the legislature and the attempt will be made to have the office of State Highway Commissioner created and laws providing state aid for the construction of roads enacted. A special committee will memorialize Congress with a view to having the government rehabilitate the national pike which traverses the states of Maryland, West Virginia, Pennsylvania and Ohio. Congress will also be asked to authorize the Secretary of War to detail engineer officers of the army to give instruction in highway engineering in Land Grant colleges, as is done now for instruction in military science and tactics.

BOSTON SOCIETY OF CIVIL ENGINEERS.—The annual dinner of the Society was held at the Hotel Vendome on March 13. Mr. John W. Ellis, M. Am. Soc. C. E., of Woonsocket, R. I., the President of the Society, presided at the exercises following the dinner. He first introduced Mr. F. P. Stearns, President of the American Society of Civil Engineers. Among the other guests and speakers of the evening were: Governor Utter, of Rhode Island; Mr. Pritchard, President of the American Gas Light Association; Prof. George F. Swain, M. Am. Soc. C. E., of the Massachusetts Institute of Technology; Mr. Harrison P. Eddy, M. Am. Soc. C. E., Superintendent of Sewers, Worcester, Mass., and President during the past year of the Sanitary Section of the Boston Society of Civil Engineers; Mr. M. N. Baker, of the editorial staff of this journal; and Mr. Henry Manley, M. Am. Soc. C. E., of Boston, who spoke for the entertainment committee of the Society. About 200 members and guests were in attendance at the dinner.

At the meeting of the Sanitary Section of the Society on March 7 the following officers were elected for the ensuing year: Chairman, Freeman C. Coffin; Vice-chairman, R. S. Weston; Clerk, W. S. Johnson; Executive Committee, H. P. Eddy, A. T. Safford, A. D. Marble.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.—The regular quarterly meeting of this association was held at the Bellevue-Stratford Hotel, Philadelphia, on March 13 and 14. General satisfaction was expressed over the brisk demand for cement already experienced at the opening of the season and the prospect for an unprecedented demand for cement throughout the year. At the Wednesday morning session Mr. Frank B. Gilbreth, of New York, described the making and driving of corrugated concrete piles, illustrating his remarks with stereopticon views. This was followed by a paper on sand for mortar and concrete by Mr. Sanford E. Thompson, of Boston. Mr. Thompson urged greater care in the selection of sand for important works of large magnitude where the saving in cement and improvement in quality of the work will repay very thorough examinations of the sand to be used. The morning session concluded with a paper by Mr. Wm. L. Price, which in the absence of the author was read by Mr. R. W. Lesley, Past-President of the association. The title of the paper was "The Possibilities of Concrete Construction from the Standpoint of Utility and Art." The author referred especially to the new Blenheim Hotel at Atlantic City, illustrated in Engineering News of March 8, and advocated the use of concrete architecturally in a manner befitting its peculiar qualities and plasticity, instead of using it to imitate brick or cut stone.

NEW ENGLAND WATER-WORKS ASSOCIATION.—The monthly lunch and meeting of the Association was held at the Hotel Brunswick on March 14. Before the presentation of papers, Mayor Thompson, of New Bedford, was introduced and made some excellent remarks on various phases of municipal government.

Two papers were presented, one by Mr. M. N. Baker, of the editorial staff of this journal, on "Water Supply, Typhoid Fever and Diarrhoeal Diseases at Burlington, Vt., 1879 to 1905, Inclusive," and one by Mr. Edmund M. Blake, of Boston, on "The Pitometer and Its Uses." The paper by Mr. Blake followed immediately after that of Mr. Baker, and during its presentation the character and uses of the pitometer were explained by the aid of one of those instruments, which had been set up in the room where the meeting was taken place.

Some of the relations between water supply and disease for the period indicated were brought out by Mr. Baker in the paper named above. Burlington has since 1866 taken its water supply from and discharged its sewage into Lake Champlain, without any purification in either case. The distance between the water intake and sewer outlet has been changed from time to time, and always with a subsequent improvement in the quality of the supply, as indicated by such evidence as could be secured and particularly by the vital statistics of the city. The latest important change in the relative locations of the water intake and sewer outlet was made in 1894, when the water intake was extended 2¼ miles, making a distance of three miles between the two points. This was followed by a marked diminution in the typhoid death rate, but after a few years the typhoid began to increase, until in 1894 it was again abnormally high. A number of extensive tables were presented, designed to show, so far as possible, the relation between the bad quality of the water and the high typhoid, diarrhoeal diseases, and infant mortality. It was suggested that examination of the submerged intake should be made, to determine its present water-tightness or otherwise. The author also discussed the relative dangers from the sewage of Burlington discharged directly into the lake, and that of the village of Winooski and Fort Ethan Allen, which comes to the lake by a circuitous flow of some ten miles through the Winooski River, which latter discharges into the lake some 3½ miles from the intake mouth. In the opinion of the author there is more danger from the sewage of Burlington than from that of Winooski and Fort Ethan Allen.

The paper was followed by a quite extended discussion presented in both written and oral form, and further written discussion was invited by President Sedgwick. Of the discussions it may be said, for the present, that Dr. B. H. Stone, Director and Bacteriologist of the State Laboratory of Hygiene at Burlington, Vt., presented some valuable additional data relating to the probability of contamination from Winooski and Fort Ethan Allen, which he thought was more serious than the Burlington contamination, and also some information on typhoid Widal reaction tests made at the laboratory for a number of years past, which tests show a larger number of positive cases than are included in the reports of the local health officer. A written discussion was also received from Mr. Allen Hazen, M. Am. Soc. C. E., of New York City, and the oral discussion was participated in by Prof. L. P. Kinnicutt and Messrs. R. S. Weston and C. E. A. Winslow.

NEW YORK RAILROAD CLUB.—At the March meeting of the club, held on the evening of March 16, at Carnegie Hall, New York City, a paper was read by B. G. Lamme (Westinghouse Electric & Mfg. Co.) on "Alternating Current Electric Systems for Heavy Railway Service." The paper considered successively the claims of (1) the direct-current system, (2) the "portable substation system, employing alternating [illegible] rent motors and a motor-generator [illegible] tive, (3) the polyphase induction motor [illegible] Arnold electropneumatic system, and [illegible] series motor system, for adaptability to [illegible] tance railway service. The latter system [illegible] ized as being peculiarly well suited to [illegible] every respect. The author then described [illegible] the single-phase locomotives and line [illegible] being built for the New York terminal [illegible] New York, New Haven & Hartford R. R. [illegible] paper is summarized on another page of this [illegible]

Discussion of the paper was opened by Mr. [illegible] J. Wilgus (Vice-President, N. Y. C. & H. R. R. R.) and was continued by Mr. C. Townley (N. Y., N. H. & H. R. R.) and Mr. F. J. Sprague.

Mr. Wilgus opened with the assertion that [illegible] steam railway men are considering electric operation [illegible] for reasons of economy or efficiency, but [illegible] reasons due to the existence of terminal tunnels, the [illegible] of the smoke nuisance, and the like. The subsequent choice of type of electrical equipment must [illegible] primary account of safety and reliability, and next [illegible] economy. Whether third-rail or overhead conductor shall be used is a fundamental question. The only valid objection to the third-rail is its interference with maintenance and track service. An important feature of overhead line is the lack of easy adaptability to track changes. Recently, in planning for electric equipment on some 50 miles of line on the West Shore R. R., it was found that overhead construction would require a very large extra expenditure, useless at present, to provide for track changes and extensions which will be necessary in, say, ten years; mainly this fact threw the decision in favor of the third rail. Both types of construction will, probably, be necessary for the full development of the art; they are substantially of equal merit, with the advantage from the non-electrical standpoint slightly in favor of the third-rail.

The great difference between steam and electric traction, namely, that one works by self-contained units while the other is dependent on a single power supply, makes it important in electric operation to guard against wholesale interruption of traffic. The main safeguarding must be done in the layout of the current-supply system. Duplicate power station, main transmission separated from the working conductor, sectionalized working conductor, and storage batteries, are means of protection. All these have been embodied in the New York Central terminal work, but seem to be absent from the New Haven plans (except the sectionalized working conductor). It is to be noted, in this connection, that if a storage battery has value as a safeguard of continuous operation, it must be charged against an alternating installation just as much as against a direct-current system, especially when only one power station exists, as in the New Haven work, and its omission in the former would result in a cost comparison on unequal basis.

An important consideration in planning for electric operation of a heavy railway is the need for handling suburban service on the multiple-unit system. The possibility of maximum suburban or local service is one of the essential features of electric traction, due to the high accelerations which may be secured and the very flexible traffic operation through multiple-unit working.

Mr. Townley drew attention to the fact that ever since the origin of railways, railway traffic operation has been developed on the basis of self-contained units, the only available motive power. It may reasonably be expected that in electric traction, where power exists all along the line and is not tied to self-contained units, the methods of traffic operation may undergo important modification.

The New Haven railway differs from most other large railway systems, in that it is a network instead of a long line, and covers a densely populated district throughout. Moreover, all parts of it are near tidewater, and its territory includes an abundance of water powers. It is fair to conclude that if the New Haven is not well situated for electric operation then it would be hard to find a railway that is.

The question of reliability received prime consideration in designing the electric equipment for the New Haven. The system adopted has only one link, the trolley wire, between power station and train; against this a direct-current system has half a dozen links. In this point the single-phase system has the advantage in reliability over the direct-current system. Against it must be placed the larger possibility of trouble in the direct collection of current from the high-tension line; this should be small, however, compared with the gain in the other regard.

A very important feature of alternating current traction, which is of special moment in the case of the New Haven railway, is the possibility of reaching out for small, infrequent but distant service, without expensive construction. The New Haven owns a number of trolley roads in its territory, and has many opportunities for operating both local and feeder lines, of small traffic, by electric supply from the main line. The facilities offered by the single-phase alternating current system in this direction are of vital bearing in the choice of system in that particular case.